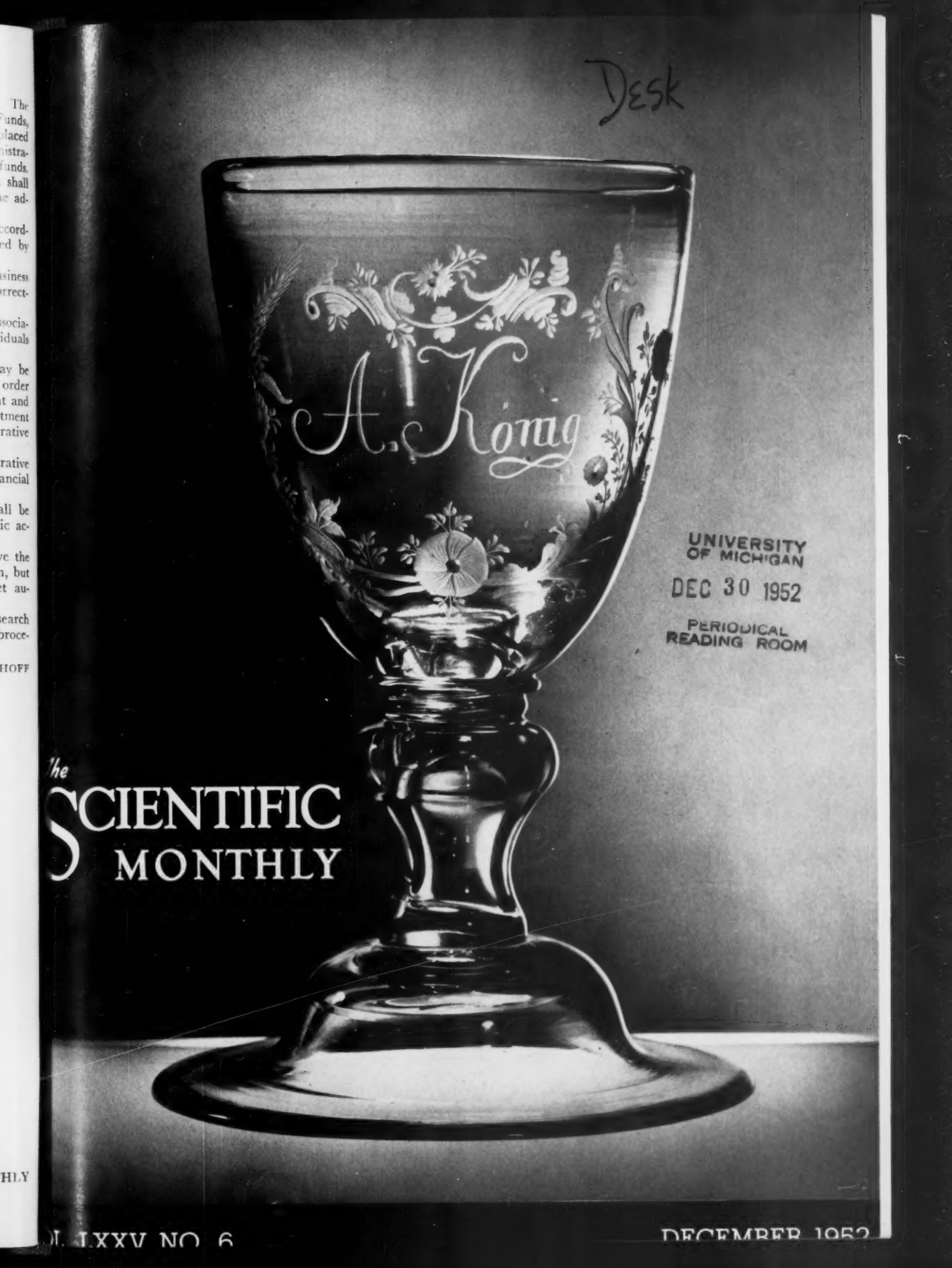

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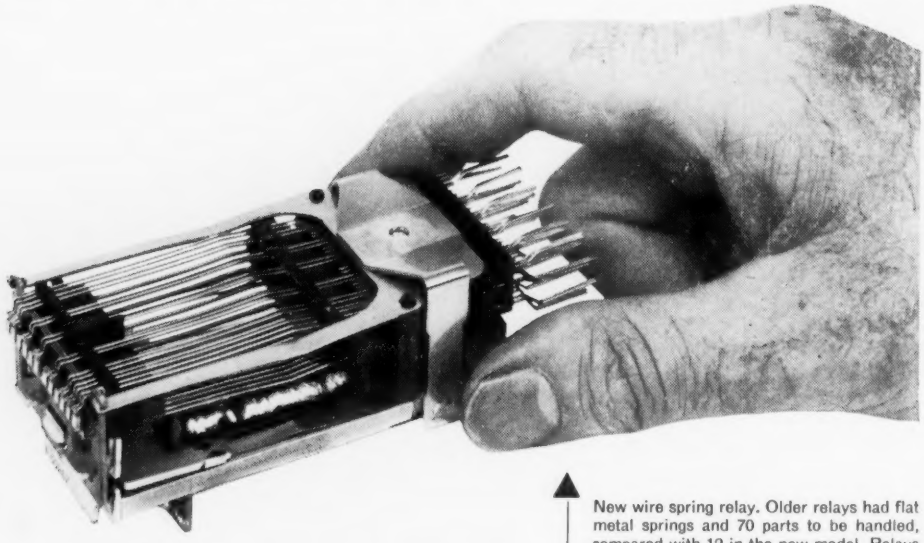
It splits seconds even faster

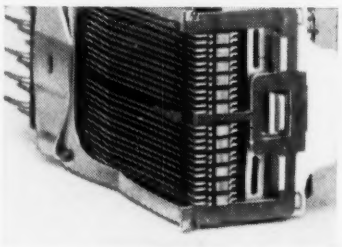


New wire spring relay. Older relays had flat metal springs and 70 parts to be handled, compared with 12 in the new model. Relays operate by means of an electromagnet which responds to high-speed pulses.

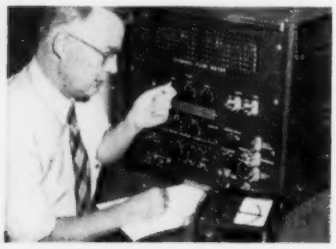
In a split second, relays, which are high-speed switches, set up dial telephone connections. Then they are off to direct the next call. Yet even this speed is too slow for Bell Laboratories scientists in quest of still faster switching.

Scientists and engineers devised a new relay – the wire spring relay – and worked out the production problem with Western Electric, manufacturing unit of the Bell System. This is twice as fast, uses less power and costs less to make and maintain.

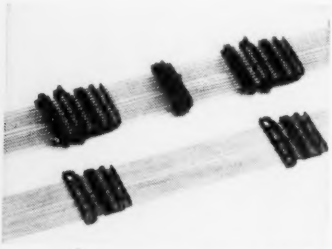
With speedier relays, switching can be done with less equipment . . . and calls go through faster. The wire spring relay is a practical example of how Bell Telephone Laboratories and Western Electric pool their skills to improve telephone service while keeping its cost down.



New relays must be able to operate one billion times—equal to once-a-second for 30 years. Employing a sound recorder as a precision vibrator, Bell scientists learned to evaluate the effect of sideways motion on relay life. Such rubbing motion is limited to one-thousandth of an inch in the new relays.



Dynamic Fluxmeter, developed by Bell Telephone Laboratories, indicates flux build-up in intervals of 25 millionths of a second. Precise information like this was essential to higher speed operation.



Relay springs as they come from Western Electric molding machine, before being cut apart for use. Molding technique saves time and money . . . makes possible the maintenance of relays in precision adjustment.

Bell Telephone Laboratories

Improving telephone service for America provides careers for creative men in scientific and technical fields.

THE SCIENTIFIC MONTHLY

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Index Issue

Annual Meeting, AAAS, St. Louis, Missouri, December 26–31, 1952

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Science and Technology

(From the Month's News Releases)

Stop Stumbling in the Dark

A device that turns your car's headlights out automatically, after you've parked in the garage or on a dark side street, gives you light for periods up to five minutes. It is easily installed underneath or through the front of the dash panel.

New Journals Received

Japanese Journal of Pharmacology. Official publication of the Japanese Pharmacological Society. Replaces *Japanese Journal of Medical Sciences,* Part IV, *Pharmacology.* Semiannual; Vol. I, No. 1, Sept. 1951. Editorial Office: c-o Department of Pharmacology, Faculty of Medicine, Kyoto University, Kyoto. . . . *The Keio Journal of Medicine.* Quarterly; Vol. 1, No. 1, Jan. 1952. $4.00, including postage. School of Medicine, Keio University, Shinjuku-ku, Tokyo. . . . *The Kumamoto Medical Journal.* Quarterly; Vol. 4, No. 2, Dec. 30, 1951. Kumamoto University College of Medicine, Kumamoto, Japan. . . . *Kyushu Memoirs of Medical Sciences* (English and other languages); Vol. 1, No. 1, June 1950. Kyushu University Faculty of Medicine, Fukuoka, Japan. . . . *Museum Pictorial.* Four or more issues per year, each restricted to a single title; No. 1, Feb. 1, 1951. 50¢ each, plus 6¢ postage. Denver Museum of Natural History, City Park, Denver, Colo. . . . *Our Public Lands;* Vol. 1, No. 3, October 1951. Issued quarterly by the U. S. Department of the Interior Bureau of Land Management.

Free Literature

The Smithsonian Institution has on hand a limited number of copies for public distribution of its *Annual Report,* with a General Appendix of articles on a great variety of scientific subjects. Scattered numbers are available, especially of issues since 1933, as well as separates of individual papers. Order by year or by title of article. *Bulletins* of the Bureau of American Ethnology, consisting of papers in ethnology, archaeology, linguistics, Indian music, etc., are also available, especially those published since 1928. Order by author and title. Requests for these publications, which will be sent free as long as the supply lasts, should be addressed to the Publications Division, Smithsonian Institution, Washington 25, D. C.

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Shady Items

Sunlight without glare can be secured by the use of plastic sheeting cut to windowpane size and applied by wetting the glass and pressing the shade against it. Properly applied, the shade will stay in place as long as desired, but may be stripped off easily by prying up a corner with a fingernail. Rinsing in warm water restores adhesiveness. Custom-cut to required size, the shades are available in eight colors.

Another new product, applied with a spray gun or a paint roller, coats windows or skylights with a clear, transparent blue-green, to cut down heat and glare.

A Venetian blind cleaner carries the cleaning fluid in a self-contained reservoir and cleans and polishes both sides of the slat in one operation, without taking down the blinds. It will not soil the tapes.

A shade pull molded of plastic slides over the bottom slat and will protect the shade from finger smudges and prevent fingers from punching through. Because it is of clear plastic it blends with the color of the shade.

This is not a view of the kitchen after a holiday party, but a scene in the Washability Laboratory in the new Research Center of Lever Brothers Company, Edgewater, New Jersey. Dishes are soiled and washed in a never-ending stream to measure the efficiency of soaps and detergents. The center was dedicated last month.

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THE
SCIENTIFIC MONTHLY
DECEMBER 1952

Amelung Glasses Compared with Some Modern Commercial Glasses

DONALD HUBBARD, LILLIE B. JENKINS, and ELIZABETH M. KRUMRINE

Dr. Hubbard has been a member of the staff of the National Bureau of Standards since 1925. He has made scientific and technological contributions in such diverse fields as photographic emulsions, production of optical glass, mountaineering, and special experiments in mental therapy. Miss Krumrine, a physicist, has been at the bureau since 1945; she analyzes miscellaneous materials, including glass, by spectrochemical methods. Mrs. Jenkins has been in the Mineral Products Section as an analytical chemist since 1944. The three authors were almost simultaneously attracted to the subject of Amelung glasses by seeing the words "Optical" and "Flints" in the early advertisements of the Amelung factory. Because of pressure from museums, historical societies, and antiquarians (as well as their own curiosity), each individual had been focusing his attention upon the subject of glass and silicate analyses.

GLASS has held a unique spell over the human race throughout all recorded history, as exemplified by the fact that glass beads have long been a favorite medium of exchange among primitive peoples. This hypnotic spell, instead of wearing off with the passage of time, has become ever more intense, until at present the more highly enlightened civilizations feel that their very survival depends upon having available adequate stores of glasses possessing certain magic characteristics such as homogeneity, specific spectral transmissions, special indices of refraction, and unique dispersions, as well as acceptable chemical, electrical, thermal, and mechanical properties. To appreciate the full magnitude of this desire, one need only experience in an optical glass factory the "witch hunting," "fatalism," and "defeatism" initiated by prolonged epidemics* of "onions," "vacuum bubbles," "convection currents," or "cathedral spires."[1] So pronounced is the hold of glass upon the human imagination that a cultured

* For primitive instructions "in combating these insidious, malefic agencies" consult: G. W. Morey. *Properties of Glass.* New York: Reinhold, 14 (1938); J. W. Mellor. The Crazing and Peeling of Glazes. *Trans. English Ceram. Soc.*, **34**, 91 (1934–35).

TABLE 1

HYGROSCOPICITY (WATER SORBED, 1 HOUR AND 2 HOURS' EXPOSURE, 98% RELATIVE HUMIDITY) OF AMELUNG AND SOME MODERN INDUSTRIAL GLASSES. UNDETERMINED CHEMICAL DURABILITIES OF AMELUNG GLASSES CAN BE INFERRED BY INTERCOMPARISON

Glasses	Water Sorbed		pH Response at pH 4.1 to pH 8.2	Chemical Durability Attack at pH		Index of Refraction Na-5889
	1 Hour (mg/cm^3)	2 Hours (mg/cm^3)	(mv/pH)	2.0 (Fringes)	11.8 (Fringes)	
Corning 015	61	125	59	2/10 – Swell	2 – Attack	1.511
Modern bottle	39	61	59	N D	1 1/2 +	—
Modern window	22	43	53	N D	1 1/4 –	1.518
Amelung clear	24	42	53	*		1.515
Amelung blue	22	41	13	*		1.5188
Amelung purple	21	40	13	*		1.5168
Amelung dark-green	20	35	0	*		1.5225
Amelung amber	—	—	—	—	–	1.5436
Chemical Pyrex	16	24	4	N D	3/4 – Attack	1.4727
Amelung light-green	14	19	0	*		—
Optical glass, flint (620)	14	19	0	D – Swell	1 –	1.620
Quartz (crystalline)	12	15	—	—		1.544 / 1.553
Fused SiO_2	10	12	0	N D	1/2 Attack	1.4584
Chemical ware, unsatisfactory for flame photometry standards						
Small cup for pH meter	41	85	59	*		—
"D" 100-ml volumetric flask	72	140	59	*		—
Series of Na_2O-CaO-SiO_2 glasses as a reference standard						
Na_2O (%) CaO (%) SiO_2 (%)						
10 20 70	14	21	0	N D	4 1/2 Attack	—
15 15 70	20	36	31	N D	7 "	1.5318
20 10 70	35	88	59	N D	7 "	1.5225
25 5 70	70	160	59	1/2 + Swell	7 "	1.513
26 4 70	80	185	59 –	2 "	7 "	1.510
27 3 70	92	219	57	6 "	12 "	1.508
28 2 70	108	249	55	18 "	36 "	1.506
29.5 0.5 70	135	314	42	75 "	144 "	1.503
30 0 70	152	379	19	126 "	252 "	1.5017
Lindemann glass transparent to X-rays						
Li_2O (%) BeO (%) B_2O_3 (%)						
15.3 2.6 82.1	182	402		—	—	—

* No specimen available

and informed person may approach the site of an early American industrial plant, such as that of Johann Friedrich Amelung† at New Bremen, near Frederick, Maryland, with the mixed emotions of a pilgrim at a sacred shrine. The more crass individual probably arrives with his digging tools and the wild-eyed, expectant mien of a gold prospector, beachcomber, or grave robber.

Whatever the character of the individual, he is at once filled with consternation to find upon arrival that someone has visited the site earlier and carried out excavations for cullet specimens with a bulldozer, thereby destroying forever the possibility of ascertaining the original furnace and factory layout, which may have been perfectly obvious prior to this enthusiastic research.‡ Patient digging beyond the reaches of the denuded area, however, will reward the individual with specimens of the furnace and pot refractories and with ample cullet samples of the many types of glass produced by the versatile Amelung enterprises: water whites, ambers, smokies, light and dark greens, permanganate blacks, purples and pinks, and cobalt blues covering a considerable range of color intensity. One has only to see or read about some of the surviving authentic Amelung articles, especially the signed presentation and memorial pieces (see photographs), to appreciate the cultural artistry and technological skill attained by his artisans.[2-4] Johann Friedrich Amelung, under contract to a group of Bremen banking houses, came to America in 1784 and brought with him from Germany experienced glassworkers skilled in all phases of the art. The magnitude of this early American glass factory can be judged by the fact that at one time it employed as many as 500 people. At the time the New Bremen Glass Works was offered for sale in 1795 the assets listed were 2000 acres of land, 30 one- and two-story dwelling houses, two glasshouses, two flattening houses, warehouses and stables, buildings for boiling potash, and a mill seat.[4, 5]

The present investigation was undertaken to obtain some idea as to how these early American industrial glasses compare in chemical and physical properties and in composition with the glasses available at the middle of the twentieth century.

The glasses chosen for study and analysis were those which corresponded in appearance to unbroken specimens of glassware in the Stohlman collection of the Amelung period. Mrs. Martin A. Stohlman selected the five glasses to be analyzed as most characteristic of the Amelung types, and generously supplemented our meager supply with additional quantities of glass which she and Dr. Stohlman had recently excavated at the ruins of the Amelung factory. Some of the samples obtained by digging consisted of broken curved pieces of free-blown or molded containers, probably cullet. Obviously, some of the other samples were parisons broken from the blowing-iron after being partially formed and having a central bubble blown. Still other specimens collected were friggers. Larger pieces seemed to have been parts of melts unused when the fires were drawn at the time the factory ceased to operate. Every effort was made to identify and avoid "crud"—glasses of furnace drippings, pot corrosion, and unsightly nonrepresentative conglomerates.

Hygroscopicity. Although there is no single test that is entirely satisfactory for evaluating all types of glasses for the myriad services that glass is called upon to perform, a few simple tests do give much pertinent and interesting information. For example, a simple hygroscopicity test tells much concerning the ability of a glass to maintain a clear polished surface upon exposure to air, a property entirely distinct from the ability of the glass to withstand attack by solutions. The method consists of weighing the water sorbed by powdered samples of glass when exposed to the high humidity (approximately 98%) maintained by a saturated solution of $CaSO_4 \cdot 2H_2O$.

Typical data for the hygroscopicity of five Amelung and some modern commercial glasses covering a liberal cross section of present-day usage are listed in Table 1 and plotted in Figure 1. Inspection of the figure reveals at a glance that all the Amelung glasses are equal or superior (lower hygroscopicity) to the sample of the modern window glass tested. The Amelung dark-green is superior to the window glass; the Amelung light-green is even less hygroscopic than Pyrex chemical glassware No. 7740, equals a modern optical glass (lead oxide flint, F 620), and approaches the values obtained for fused silica. In the light of the modern practice of acid surface treatment of finished blown containers, of one-trip bottles, and the need for

† Two trips were made to the factory site for specimens of glass: the first with Francis W. Glaze and Gerald F. Rynders, the second in company with Conrad A. Faick and John H. Hubbell.

‡ Although the archaeologist and the anthropologist, who do so much of their excavation of delicate specimens with tiny trowel, brush, and toothpick, may be horrified at this bulldozer technique, nevertheless it has resulted in an attractive, instructive, and easily examined exhibit presented by Mrs. W. R. Milford to the Maryland Historical Society, of Baltimore, which displays all the types (colors) of glasses produced at the New Bremen works. No student of antique American glass can afford to overlook this mounted collection of Amelung cullet.

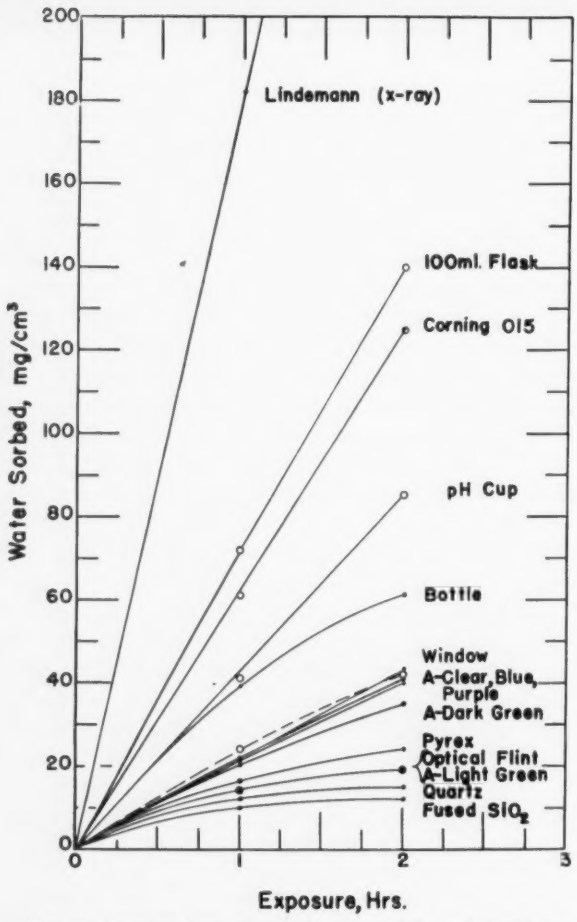

FIG. 1. Comparison of the hygroscopicity of Amelung glasses (early U. S. industrial 1785–95) with present-day glasses (1951).

economy in production, it is easy to understand the reason for many modern container glasses being "so poor," but it is not so easy to rationalize why Amelung should have gone to the effort and additional expense to produce glasses that were "so good." Possibly the cheapness of fuel (wood), limited supply of alkali salts (potash), and the local abundance of limestone were contributing factors.

Among the other commercial glasses included in Figure 1 is Corning 015, an electrode glass produced because of its superior voltage (pH response) characteristics.[6] Adequate hygroscopicity is a vital factor in the successful functioning of such a glass.[6] The 100-ml volumetric flask and small pH meter cup (identified as "pH cup" in the figures) are of interest because they represent examples of undesirable laboratory glassware on the market that have contaminated standard reference solutions used in precise flame photometer experiments.[7] The 100-ml volumetric flask is an interesting example of a glass high in SiO_2 content, but still much too hygroscopic to meet the exacting analytical requirements demanded in flame photometry.

The Lindermann glass is a special-purpose glass used only because of its superior X-ray transmissivity.§

pH Response. Any glass upon immersion in an aqueous solution develops an electromotive force. For many glasses this voltage serves as a reliable indicator of the hydrogen ion activity of solutions. Previous investigations have shown, however, that electrodes prepared from glasses of low hygroscopicity fail to develop the full increment of voltage indicated by the Nernst equation $\Delta E = 0.000198\ T\ \Delta pH$.[6] This failure of electrodes to act as indicators of hydrogen ion activity of aqueous solutions can be used in a general way as a rapid indicator of the serviceability of optical glasses.

The pH response of the glasses was obtained with mercury-filled electrodes of the Cremer-Haber thin-bulb type,[6] prepared from tubing obtained by remelting samples of the Amelung glasses. The remelting and tube drawing were necessary because the Amelung glasses could not be sealed to either the soft or hard modern glass tubings available. A well-conditioned glass electrode was used as the reference electrode. This test, when applied to the Amelung glasses for comparison with the modern commercial glasses, gave the results plotted in Figure 2. Electrodes prepared from the light- and dark-green Amelung glasses gave little or no definite pH response—i.e., they exhibited large voltage departures, as was also the case for the optical glass, F 620, fused silica, and chemical Pyrex. Thus once again the Amelung glasses fell into a superior class. Likewise, the Amelung clear glass checked the behavior of modern window glass. The 100-ml volumetric flask and the small pH cup glasses gave the full pH response (no voltage departure) over the range pH 4 to pH 8, thereby showing themselves to be glasses of inferior chemical durability, or borderline glasses, along with Corning 015 and the commercial bottle glass. The bottle provides a convenient reference glass, as its quality is entirely adequate for many but not all commercial uses.

Unfortunately, the reliability of this pH-response test as an indicator of serviceability breaks down in the case of glasses of high hygroscopicity having very poor chemical durability. For such glasses large voltage departures appear which might erroneously be classified as indicative of superior properties. For examples see soda-lime-silica glasses

§ This sample was prepared and donated by Antonio C. Bonanno, of the Portland Cement Association Research Fellowship.

listed in Table 1 and plotted in Figure 3.

Figure 3, in which the pH response (mv/pH between pH 4 and pH 8) of the Amelung and modern commercial glasses is plotted against the hygroscopicity (water sorbed in one hour's exposure to the high humidity maintained by a saturated solution of $CaSO_4 \cdot 2H_2O$), probably gives the most understandable picture of the relative position of the various glasses. In this figure the results for a series of Na_2O-CaO-SiO_2 glasses containing 70 per cent SiO_2 (Table 1) are also included as a ready reference standard for comparison of pH response, hygroscopicity, chemical durability, and composition. This soda-lime-silica series is included to emphasize the fact that glasses of high hygroscopicity which fail to give full pH response are not satisfactory for general commercial usage because of very poor or inferior chemical durability—i.e., they show excessive attack in alkaline buffers and pronounced swelling in acid solutions.‖ The glasses that have intermediate values of hygroscopicity and develop the full pH response of 59 mv/pH at 25° C often have certain special uses, but must be classified as borderline, or intermediate, glasses. All glasses so far tested having superior serviceability (ability to maintain clear polished surfaces upon exposure to atmospheric conditions) or superior chemical durability (resistance to attack by aqueous solutions), or possessing both of these desirable properties, have fallen into the group of glasses exhibiting low hygroscopicity and have also failed to develop full pH response. It must be borne in mind, however, that many glasses appearing in this group do not possess both of these desirable virtues; notable examples of this are the optical glasses previously studied that exhibit excellent serviceability because of low hygroscopicity but possess unusually poor chemical durability.

It is obvious from Figure 3 that the 100-ml volumetric flask is in poor company, the bottle and small pH cup are in a questionable environment, and the Amelung glasses are all in the superior section.

Uneven Distribution of Migratable Ions at the Glass-Solution Interface. Figure 4 and Table 2 show the results obtained from experiments on the uneven distribution of migratable ions at the glass-solution interface.[9] The indicator ion chosen in these experiments was the complex $Ag(NH_3)_2^+$ which remains in excess in the silica-rich surface formed upon leaching the glass at pH 2 for various lengths of time. This excess $Ag(NH_3)_2^+$ is readily titrated potentiometrically after acid neutralization. The method appears to differentiate readily glasses

‖ The chemical durability measurements reported were obtained by an interferometer procedure which gives values in wavelength of light for the surface alteration of the glass upon exposure to solutions under controlled conditions of time, temperature, and pH.[8] The 5876 A line of helium light was used as the reference standard of length.

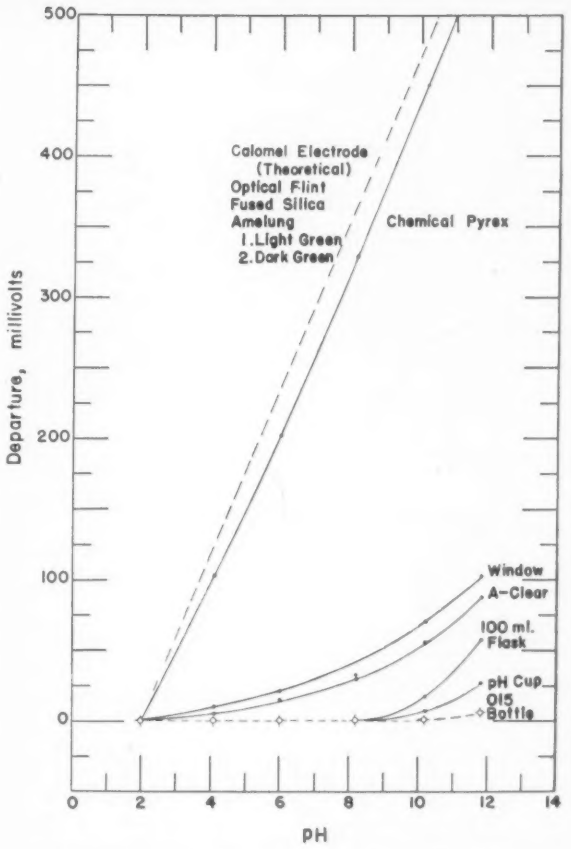

FIG. 2. Comparison of the pH-voltage departure curves for electrodes prepared from Amelung glasses (early U. S. industrial) and some modern industrials (1951).

TABLE 2

EXCESS $Ag(NH_3)_2^+$ IONS FOUND IN THE SURFACE OF POWDERED SAMPLES OF AMELUNG LIGHT-GREEN AND FOUR MODERN INDUSTRIAL GLASSES (1951), LEACHED AT PH 2, 80° C FOR VARIOUS PERIODS OF TIME

Glass	Excess $Ag(NH_3)_2^+$ Ion		
	0 Hour (mEq/g)	6 Hours (mEq/g)	24 Hours (mEq/g)
Corning 015	5.8×10^{-4}	11.2×10^{-4}	17.6×10^{-4}
Modern bottle	1.0 "	3.4 "	6.9 "
Amelung light-green	< 0.2 "	2.9 "	3.8 "
Pyrex	< 0.2 "	1.3 "	2.3 "
Fused SiO_2	—	1.5 "	—

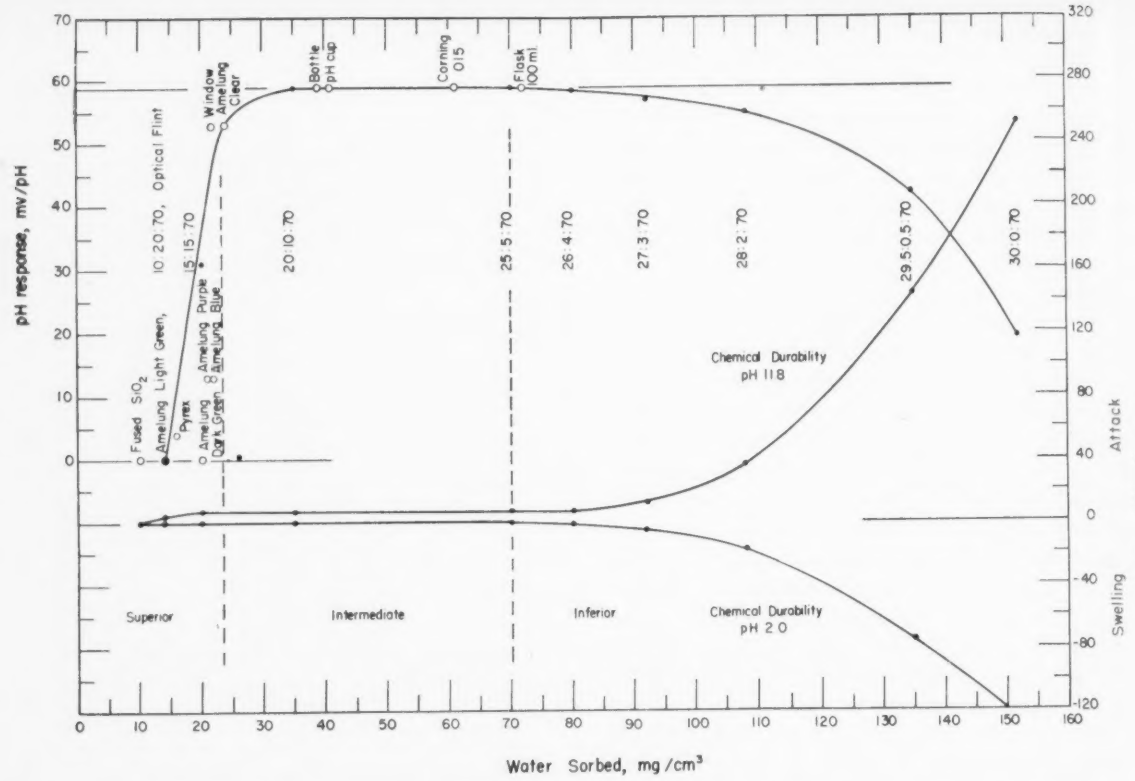

FIG. 3. Variation in pH response of electrodes prepared from early American (Amelung) and modern industrial glasses compared with the hygroscopicity of the glasses. The pH response, hygroscopicity, and chemical durability at pH 2 and pH 11.8 for a series of experimental glasses (Na_2O-CaO-SiO_2 containing 70 per cent SiO_2) are included as a reference standard.

of different chemical durabilities. In the present case the Amelung glass investigated once again occupies a superior position.

The uneven distribution of migratable ions between the inner and outer phases (the glass surface and the ambient solution, respectively) produces osmotic pressures within the surface of the glass, causing swelling and ultimate destruction of the specimen. If a reliable quantitative determination of the uneven distribution of migratable ions could be obtained, it undoubtedly would furnish a pertinent indicator of the chemical durability of glasses. Certainly, the fidelity of the surface exhibited by some examples of Amelung glasses that had been exposed to combined atmospheric and ground weathering for more than a century and a half is in accord with the favorable classification indicated for them by this test.

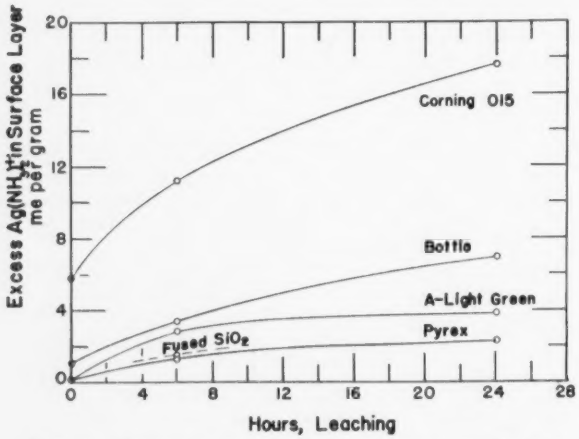

FIG. 4. Comparison of the heterogeneous equilibria at the glass-aqueous solution interface of Amelung light-green with three modern industrial glasses after various times of leaching at pH 2, 80° C.

Expansion Characteristics. So much difficulty was encountered in obtaining modern commercial glass tubing on which a button of Amelung glass might be sealed and blown for experimental glass electrodes for pH response data that it became imperative that the Amelung glasses be remelted and tubes drawn before successful electrodes could be prepared. In the remelting operation it became evident that these "old" glasses had working temperatures considerably higher than any of the modern commercial glasses studied, with the exception

of fused silica and Vycor. In fact, considerable difficulty was experienced in handling the glasses at the highest temperature (1500° C) to which the technicians cared to force the Globar furnaces. These experimental difficulties made it of interest to determine the annealing and softening temperatures and to compare the expansion characteristics of a typical Amelung glass with a few of the modern glasses that have unusual properties or applications for special purposes (Table 3 and Fig. 5). These expansion measurements were made according to the Saunder's modification[10] of the Fizeau interferometric method, because it is particularly well adapted to obtaining accurate results on small specimens.

Figure 5 offers a ready comparison of the Amelung light-green with chemical Pyrex, which latter glass is marketed because of its special thermal shock and desirable chemical durability characteristics. This Amelung green has an annealing temperature (the so-called critical temperature) at least 75° C higher than Pyrex, and a softening temperature approximately 30° C higher. This is most remarkable in light of the fact that Pyrex types of borosilicate glasses were long delayed in coming to mass production because of the difficulty of producing refractories adequate for their manufacture. Similar comparison reveals that this Amelung green has higher softening and annealing temperatures than even Kimble N 51-A. The latter glass is of interest because of its intermediate expansivity, but more particularly because of its superior chemical durability in alkaline solutions.

Bearing in mind the moderately high coefficient of expansion and high annealing temperature shown by the expansion curve, we observed many of the samples of Amelung glasses found at the old factory site in polarized light for birefringence indicating strain and degree of annealing. A well-annealed sample of glass is isotropic and shows no rotation of the plane of polarization, whereas the same sample, upon rapid cooling from above to below the critical temperature, is anisotropic. All the samples of parisons, friggers, broken containers, and bulk glass inspected showed heavy strain. It was most interesting to examine the fourteen authenticated Amelung articles assembled for the special 1952 exhibit by the Maryland Historical Society in Baltimore.¶ All of them possessed moderate to considerable strain, particularly in the stems of the goblets.

¶ Special thanks are due Curator James W. Foster, who made this inspection possible, and to Eugenia Calvert Holland, who calmly accepted the responsibility of handling these priceless articles.

TABLE 3

EXPANSIVITY, CRITICAL, AND SOFTENING TEMPERATURES OF AMELUNG LIGHT-GREEN AND A FEW MODERN GLASSES COVERING A WIDE RANGE OF USES

Glass*	Expansivity 100°–400° C (cm/cm/°C)	Critical Temperature (°C)	Softening Temperature (°C)
Corning 015	11.6×10^{-6}	500	555
Modern window	9.8	505	585
Optical glass, F 620	9.7	390	475
Amelung light-green	8.8	575	645
Kimble N 51-A	5.1	550	640
Pyrex	3.2	500	615
Vycor (96% SiO_2)	7.8×10^{-7}	790–890	—
Fused silica	5.5	1070–1140	—

* These data, with the exception of those for Amelung light-green, Vycor, and fused SiO_2, were obtained by Laurel H. Maxwell. The Amelung characteristics were determined by Oscar H. Grauer, and the values for Vycor and fused SiO_2 are those given by C. J. Phillips in *Glass, the Miracle Maker*. New York: Pitman Pub.

Corning 015 is included in the comparison because for many years it was the best glass available for the production of glass electrodes having a preferential voltage response to hydrogen ions in aqueous solutions to the near exclusion of all other ions.[6] It has the approximate composition Na_2O,

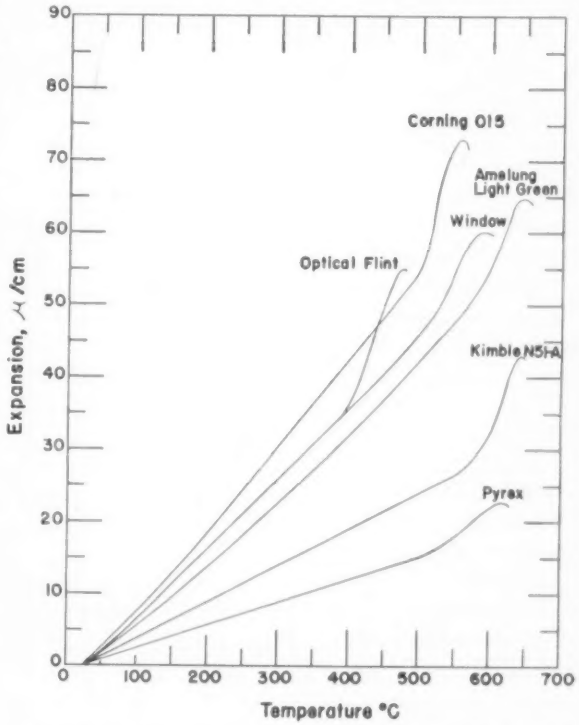

FIG. 5. Comparison of the expansion, annealing, and softening temperature characteristics of Amelung light-green with five modern glasses.

TABLE 4

SPECTROCHEMICAL ANALYSES (QUALITATIVE)* OF FIVE CHARACTERISTIC AMELUNG GLASSES†

Element	1	2	3	4	5	Element	1	2	3	4	5†
Ag	—?	—?	T	T	—?	Mo	—	—	—	—	—
Al	S	S	M	S	M	Na	S	S	M	M	S
As	VW	VW	VW	VW	VW	Ni	VW	VW	W	—?	—?
Au	—	—	—	—	—	Os	—	—	—	—	—
B	VW?	VW	VW	VW	VW	P	—	—	—	—	—
Ba	M	M	M	M	W	Pb	W	W	M	M	VW
Be	—	—	—	—	—	Pd	—	—	—	—	—
Bi	—	—	W	—	—	Pt	—	—	—	—	—
Ca	S	S	S	S	S	Rb‡	—	—	—	—	—
Cb	—	—	—	—	—	Rh	—	—	—	—	—
Cd	—	—	—	—	—	Ru	—	—	—	—	—
Ce	—	—	—	—	—	Sb	—?	—?	VW	VW	VW
Co	—?	—	M	—	—	Sc	—	—	—	—	—
Cr	VW	VW	VW	VW	VW	Si	VS	VS	VS	VS	VS
Cs‡	—	—	—	—	—	Sn	VW	VW	—?	VW	—?
Cu	VW	VW	VW	VW	VW	Sr	M	M	W	W	W
Fe	M	M	W	W	W	Ta	—	—	—	—	—
Ga	—	—	—	—	—	Te	—	—	—	—	—
Ge	—	—	—	—	—	Th	—	—	—	—	—
Hf	—	—	—	—	—	Ti	M	M	W	W	W
Hg	—	—	—	—	—	Tl	—	—	—	—	—
In	—	—	—	—	—	U	—	—	—	—	—
Ir	—	—	—	—	—	V	VW	—?	—?	—?	—?
K	S	S	S	S	S	W	—	—	—	—	—
La	—	—	—	—	—	Y	—	—	—	—	—
Li‡	—	—	—	—	—	Zn	—?	—?	—?	—?	—?
Mg	M	M	W	W	W	Zr	—?	—?	—?	—?	—?
Mn	M	M	M	M	VW						

* The qualitative scale used in reporting the relative amounts of the elements in the samples is as follows:

Designation and Scale Value					
VS	Very strong	(Greater than 10%)	VW	Very weak	(0.001–0.01%)
S	Strong	(1–10%)	T	Trace	(0.0001–0.001%)
M	Moderate	(0.1–1.0%)	—	Not detected	
W	Weak	(0.01–0.1%)			

† Label of sample: Amelung Glass #1, Dark-Green; #2, Light-Green; #3, Blue; #4, Purple; #5, White, clear.
‡ Limit of detection for the alkali elements is estimated to be 0.05%.

22 per cent, CaO, 6 per cent, and SiO_2, 72 per cent, which places it near the eutectic composition having the lowest melting temperature for any composition of the equilibrium diagram for the soda-lime-silica system.[6]

It has often been suggested that Amelung may have used appreciable quantities of lead oxide in some of his glass melts. The expansion curve for a typical modern optical glass, F 620, containing 45.1 per cent lead oxide is included in Figure 5. The conspicuously low softening temperature, 475° C, is characteristic of such glasses. From this evidence alone it would appear highly improbable that Amelung light-green glass contains PbO as a major constituent.

Chemical Composition. The chemical, hygroscopic, and pH-response properties, in addition to the high-temperature working range of the Amelung glasses, were so unexpected that it became of interest to inspect their composition. In order to simplify the work for the chemist in making the final quantitative analyses, a preliminary qualitative spectrochemical determination was made, thereby reducing the likelihood of overlooking any pertinent or interesting constituents of the glasses. The effectiveness of this procedure is easy to appreciate; essentially all the metallic elements of the periodic table are covered, and the elements are reported as being present in major, minor, or negligible proportions. The spectroscopic analytical techniques employing the same equipment used in this work have been described by Scribner.[11, 12] By comparing the relative intensity of the spectral lines appearing in the sample with those in the standards having known concentrations, the concentration of the metallic elements was estimated. Future work, with closer spacing of the known limiting standards, will make it possible to obtain quantitative analyses of glass articles without sacrificing the specimen, as only 5 mg of the glass are required.

Table 4 gives the results of spectrochemical analyses, and Table 5 the quantitative analytical data obtained on the five selected types of Amelung glasses excavated near the old factory site. Certain facts are readily seen from inspection of these analyses. None of the glasses contains greater than

0.49 per cent of lead oxide, PbO. This confirms the general belief that Amelung did not make glasses of the "English-Irish flint" or modern "optical flint" variety, although he used the words "flint" and "optical" to describe some of his glasses.[3, 4, 13, 14] None of the specimens collected at the factory site, and no authenticated examples of Amelung glassware, have been found to contain lead oxide beyond a fraction of 1 per cent. The inappropriate modern use of the term "flint" to designate "lead" glasses is largely responsible for the confusion.

Equally obvious is the fact that his blue glasses were obtained by incorporating cobalt oxide in the melt—1.35 per cent CoO, supplemented with 0.34 per cent NiO in the sample analyzed. Although NiO is a powerful coloring agent, there seems little reason for Amelung to have added it intentionally to a glass containing cobalt oxide. The most likely explanation for the presence of NiO in this Amelung glass is that it came from the zaffer, an impure oxide of cobalt commonly used in making cobalt blue glasses. However, one must not overlook the fact that special black glasses are made by the proper proportions of cobalt and nickel oxides. An investigation of the spectral transmission of the Amelung glasses would undoubtedly make an interesting and revealing study.

Amelung's purple glasses were produced by the judicious use of manganese compounds, reported in the analysis as 2.72 per cent MnO. Other samples of glass, containing much larger amounts of manganese, were found; they were essentially opaque and had weathered badly. These may have been glasses with which, upon addition to water-white glass, Amelung made decorative smoky and purplish swirls.

From the analyses one would conclude that the shades of green were controlled by the use of iron and manganese oxides. The dark-green and light-green glasses are distinctly different in chemical composition and properties. The dark-green has as much as 1.26 per cent Fe_2O_3 and 0.64 per cent MnO, compared to 0.46 per cent Fe_2O_3 and 0.43 per cent MnO for the light-green. Further, the light-green has 2.68 per cent less total alkali and more CaO than does the dark-green, which accounts for their difference in hygroscopicity values, so evident in Figure 1. The quantities of CaO are generally higher in the Amelung than in modern container glasses, with 15.9 and 19.57 per cent CaO, respectively, for the dark- and light-greens, compared with 7.21 per cent for the modern bottle glass. These values, coupled with their moderate alkali oxide content, account for the unusually high working temperatures of Amelung glasses.

So high were the working temperatures found upon remelting these glasses that one wonders how Amelung was able to melt, fine, and work the

TABLE 5

COMPOSITIONS (In percentages)

	Amelung					Commercial (1951)						
Oxides	Dark-Green	Light-Green	Blue	Purple	White	Pyrex	Kimble N 51-A	Volumetric Flask (100 ml)	Electrode Glass, Corning 015	Window Glass	Bottle Glass	Optical F 620
SiO_2	65.74	66.50	69.58	69.34	67.72	80.5	74.7	74.88	72.0	72	70.70	45.6
TiO_2	0.36											
B_2O_3						12.9	9.6	0.64			0.41	
Al_2O_3	4.86	2.96	0.82	1.50	0.96	2.2	5.6	1.05		1.2	1.95	
Fe_2O_3	1.26	0.46						0.05				
As_2O_3							0.03					0.5
BeO												
MgO	0.84	1.72	0.23	0.27	0.28		6.4	1.36		2.5	5.34	
CaO	15.90	19.57	10.18	12.22	13.61		0.9	2.86	6.0	10.3	7.21	
SrO	0.04	0.01	0.08	0.06	0.01							
BaO	0.23	0.22	0.18	0.20	—		2.2	0.004			0.65	
ZnO							0.1	1.62				
PbO	0.00	0.00	0.49	0.45	0.0			0.0				45.1
MnO	0.64	0.43	0.43	2.72	0.11			0.13				
CoO			1.35									
NiO			0.34									
Li_2O												
Na_2O	1.67	3.09	0.82	0.31	3.60	3.8	6.4	17.51	22.0	14.0	13.20	3.6
K_2O	8.80	4.70	15.99	13.10	13.81	0.4					0.55	5.2

Covered sweetmeat jar of clear greenish glass. Courtesy Metropolitan Museum of Art.

finished glass. The use of small melts, possibly of the "jockey" type, and auxiliary draft were undoubtedly important aids. Possibly he obtained additional heat by the use of rosin. Certainly the "rosin monkey" practice was prevalent in the glass industry only a short time later.[3]

From the compositions of Amelung's glasses some rather positive conjectures can be made concerning the nature of his raw materials. Potash (leached wood ashes) was probably the chief source of his alkali, because with the exception of one glass the ratio of Na_2O/K_2O is low. The CaO was obtained from limestone of a fair quality, quite obviously not of the dolomitic type, which latter contains large percentages of magnesia, MgO. In fact, three of the glass compositions show less than 0.3 per cent MgO, and it is only for the dark- and light-green glasses that larger quantities of MgO are found. Lansing S. Wells, of the National Bureau of Standards, points out that the limestone deposits in the vicinity of Frederick, Maryland, are of high CaO and low MgO content. Apparently, barium, lead, strontium, and titanium oxides in Amelung glasses are chance impurities. The small percentages of PbO (less than 0.5 per cent) might easily have been introduced in cullet derived from glasses of foreign origin. However, it would appear to be more than mere chance that these small percentages of PbO should have been confined to his blue and purple glasses. Whether he added these small amounts purposely to gain certain known beneficial effects for working the glass, engraving, or general appearance can be decided only by additional investigation.

Indices of Refraction. The mention of "optical glass" in Amelung's announcement of types to be produced,[2, 13] followed by continued advertisements of "flints,"[14] naturally raises the question concerning the indices of refraction of the glasses that he manufactured. Although Amelung's colored glasses have absorption bands in the yellow region of the visible spectra, making them practically opaque to the yellow sodium light used in the index

The Bremen Pokal. Presented by Amelung to the City of Bremen. Courtesy Metropolitan Museum of Art.

Mifflin goblet of clear colorless glass engraved with the Arms of Pennsylvania; said to have been presented to Governor Thomas Mifflin. Courtesy Metropolitan Museum of Art.

determinations, values were obtainable by the Faick-Fonoroff instrument, which is uniquely adaptable to such specimens.[15] Table 1 gives values for the index of refraction obtained on five of the Amelung glasses, compared with the values for some of the modern glasses. A comparison of these low indices, approximately 1.52, with the index 1.620 for the optical glass, is in accord with the analyses which show that lead oxide is not a major constituent of the Amelung glasses. The amber glass specimen, however, had an index of 1.5436, which can be duplicated by a glass containing as much as 25 per cent PbO. Unfortunately, the sample of the amber glass was very small and an analysis was not made. If larger samples of Amelung ambers are found, an analysis is imperative before one can definitely state that the Amelung factory never made glasses containing appreciable quantities of lead oxide. Certainly, however, his major types were not "lead" glasses.

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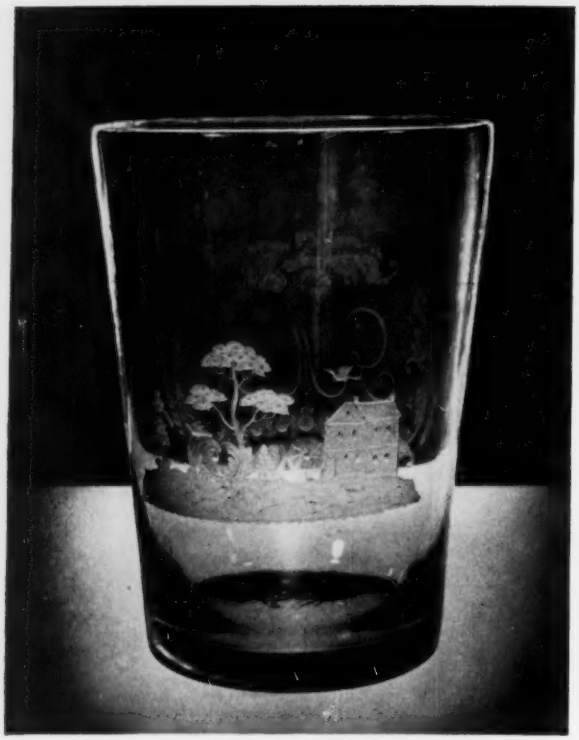
Amelung presentation piece from the McKearin Collection.



Repold flip glass. Presentation piece to George and Metha Repold. Courtesy Geo. S. McKearin.

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THE VASTER WOMB

Always a wall: always we are hemmed in,
A wall before us, and a wall behind,
While we must trace the narrow lane between
Poised on the tensile tightrope of the mind.
We are enveloped by the walls of space,
Girdled by time; whichever way we move
New walls arise, yet we must reach across
The barriers of hate through those of love.

Wall after wall, and there is no escape.
We are enmeshed in walls of flesh and bone,
Wearing but briefly some ephemeral shape
And yet forever isolate and alone,
Who edge along the corridors of birth
Only to seek the vaster womb of earth.

Mae Winkler Goodman

Cleveland, Ohio

Man's Battle Against Oblivion

HUGH H. HARTLEY

Mr. Hartley, one of those rare natives of Washington, D. C., has been an examiner for the Indian Tribal Claims Section, General Accounting Office; librarian of the U. S. Coast and Geodetic Survey (1927–43); and served as assistant to the air adjutant general, GHQ, during World War II.

THE desire to be favorably known and perpetually remembered, lacking the ability to exist forever, is inherent in all men. These desiderata form the prime drive in carrying on the individual battle of some men against oblivion. Many of those who have attained a level of development above the acquisition of creature comforts have put forth efforts toward this end, herculean in some instances, as demonstrated by the remains that have survived in the form of writings, temples, and inscribed monuments.

The choices of endeavor toward attaining fame and remembrance lie principally in the fields of literature, architecture, art, conquest through geopolitics abetted by warfare, the professional services, such as teaching, law, medicine, religion (with its concomitant altruistic endeavor), and science, pure and applied. Even the followers of Gautama Buddha whose sole aim of existence is attainment of nirvana,[1] the complete cessation of the obligatory transmigrations of the soul in different forms of being via the path of karma, strive for perfection. They, too, have left to us some vestiges of the immediate aforementioned fields that in part equal those that now remain from members of other cults who identify themselves with Deity, and who believe that they might continue to exist, not only in spirit and soul, but in pristine individual body as well. Hence the *modus operandi* in the battle against oblivion is the same for those who desire to win eventually against it as well as for those who desire to attain it as an end.

The memorabilia of man *versus* oblivion are depicted in the fragments that have survived to us from the dawn of antiquity—extensive enough in some instances to indicate the vaster whole.

Survival of Man's Writings

Outstanding among the survivals of the earliest writings, some mere fragments, others copious and in good state of preservation, are man's religious works. These hagiographa[2] disclose man's attempt to identify himself with Deity and the establishment of rules of conduct, exhibiting his concern for personal perpetuity. This concern is manifested by the obvious care he must have given his religious writings, in that the oldest and best-preserved survivals among books that antedate the incunabula of printing are religious works, lettered and illuminated on papyrus, vellum, and other fabrics. Notable among these is the Book of the Dead, the Papyrus of Ani, chancellor of the ecclesiatistical revenues and endowments of Abydos and Thebes. This funeral book was in vogue among the Theban nobles *circa* 1500 to 1400 B. C., and an original papyrus is now among the rare treasures of the British Museum. A transcript of this papyrus, with interlinear translation in English text in a printed folio, by E. A. Wallis Budge,[3] Litt.D., sometime keeper of Egyptian and Assyrian antiquities, British Museum, bearing the imprint date 1894, is on file in the Library of Congress. The oldest parts of the Book of the Dead that now survive in museums hark back, as near as can be established, to 4000 B. C. Among man's other earliest discovered writings that have defied the tooth of time are, chronologically:

6000 B. C.—Chaldean texts from the Temple of Nippur
4241 B. C.—Calendar devised in Egypt
3600 B. C.—Oldest papryus writings in Egypt
3000 B. C.—Oldest records found in Assyria
2700 B. C.—Written records in China
1500 B. C.—Rig-Veda in India

Thus do the remnants of man's earliest writings serve to mark his efforts to achieve immortality since the dawn of recorded history.

Selected Structures Built by Man

Turning now from brief mention of man's written records, let us consider his efforts permanently to establish his memory through architectural monuments:

The Great Pyramids at Giza, Egypt
The Hanging Gardens of Babylon
The Statue of Zeus at Olympia
The Temple of Diana at Ephesus
The Tomb of Mausolus at Halicarnassus
The Pharos, or Lighthouse, of Alexandria
The Colossus of Rhodes
The Colosseum at Rome
The Catacombs of Alexandria
The Great Wall of China
Stonehenge, Salisbury Plain, England
The Leaning Tower of Pisa
The Porcelain Pagoda of Nanking
The Mosque of St. Sophia at Istanbul

Other man-made mementos include:

The Taj Mahal at Agra, India
The Stone Images of Easter Island in the Pacific
The Mayan temples in Yucatán, Mexico
Christophe's Citadel of La Ferrièrre, Haiti, high on a mountain (10,000 workmen died building it)
The Great Serpent Mound, Adams County, Ohio, 1300 feet long, with coiled tail and cobra head (built by the Mound Builders)
The Acropolis at Athens (especially the Parthenon)—considered the most beautiful buildings ever constructed by the Greeks
Pompeii, the city buried by an eruption of Vesuvius in A. D. 79, now exhumed
The Diwan-i-Khas of Shah Jehan's palace—particularly the jeweled room—Delhi, India
The 10,000 Temples at Pagan in Burma, partially destroyed A. D. 1250
Petra, the rose-red quartz city in the Arabian Desert
Sanjusangendo at Kyoto, temple of 33,333 gods, built A. D. 1132
The Colossi of Memnon, at Thebes, Egypt, 70 feet high, representing Amenhotep III and his consort, Taia (the temple built to guard them has disappeared)
The Great Sphinx of Egypt, a man-headed lion god, 189 feet long, 66 feet high, with a roofless temple between the paws. It was shaped from hard mud and tiled with rock

Many other temples and monuments have undoubtedly been erected by man to his own memory; unrecorded, unknown, or forgotten, they have succumbed to the inexorable ravages of time, the barbarous forces of war, and the ruthless hands of vandals. Of the latter destruction, mention need only be made of the deliberate disfiguration of the Sphinx by Napoleon, who, when he could not transport such a huge monument, ordered the nose chopped off; this he carried to France as an inglorious memento of his peregrinations in search of personal glory. The Napoleonic military campaigns are now forgotten by nearly all save the students who attend higher military academies, and Napoleon is chiefly remembered for the *Code Napoléon*, a codification of the law extant in France during his reign, which followed the French conquests and is still in force in many areas.

Fame is the Spur

Some have striven prodigiously for fame and others have accidentally become famous. Representative of the latter is the Pharaoh Tutankhamen (fl. about 1358 B. C.),[2] who ruled from the age of twelve to eighteen. He came to the throne at a time when there was almost complete demobilization and disintegration of the government of Egypt. Since the affairs of state were mainly conducted by a regent, he could do but little toward perpetuation of his memory. What was done to that end came about through the funeral customs of royalty. Two hundred years after his death the builders of the elaborate tomb of Rameses VI on the cliff above the site of Tutankhamen's small-sized tomb threw the waste material and limestone rubble over the side, completely covering Tutankhamen's tomb; it lay hidden until discovered and excavated by Howard Carter in 1923–24 under the patronage of Lord Carnarvon. During the period immediately following the discovery of the tomb of this unillustrious Pharaoh some of the world's leading periodicals printed elaborate reproductions of Egyptian attire and furniture *circa* 1350 B. C. This resulted in the bringing out by fashionable *couturiers* of copies of the colorful vestments worn by the Egyptians more than three thousand years before.

In contrast with the accidentally famous is Alexander III (356–323 B. C.) son of Philip II of Macedon, known now even to school children as Alexander the Great. Peter Bayle in his herculean work, the *Historical and Critical Dictionary*,[4] said of Alexander in an extensive, copiously footnoted article:

> Alexander the Great King of Macedonia was born the most extraordinary man in the world, and if all that the books tell us of him be true, he was not so much a man as an incarnate intelligence. It seems as if providence made choice of him to demonstrate to the world, how far the powers of a human instrument can reach when the time of the most wonderful revolution is come. [At about 1690 what revolution did Bayle have in mind?]
>
> On one hand he was impious enough to be a god and on the other he was superstitious even to a womanish weakness.

Alexander is remembered also as the one who cut the Gordian knot.

Not too remotely associated is the fame of Phryne,[2] the Greek courtesan, with that of Alexander. Born at Thespiae, Boeotia, during the fourth century B. C., she was originally given the name of Mmesarete. She lived for the most part at Athens, where she plied her trade equally among patricians and plebeians. She, too, longed to be remembered after her beauty failed and her mundane existence

endec. This is evidenced by the record that relates: "She acquired so much wealth as a courtesan she offered to rebuild the walls of Thebes on condition that the legend 'Destroyed by Alexander, restored by Phryne the Courtesan' be inscribed thereon." Her wish was not granted, mainly because of the hypocritical morality that existed even in those times. She was, however, elevated to undying fame, for, on the occasion of a festival of Poseidon at Eleusis, she laid aside her garments, walked naked to the sea, and stepped into it in sight of the populace. This suggested to the painter Apelles his great picture of Aphrodite Anadyomene, for which she sat as a model. She also modeled for the Cnidian Aphrodite by Praxiteles. A statue of Phryne as herself, the work of Praxiteles, was placed in a temple at Thespiae beside that of Aphrodite by the same artist. For profaning the Eleusinian mysteries she was defended by the orator Hypereides. When it appeared that the verdict might be unfavorable, he rent the clothes from her body, and when the judges beheld her seductive beauty they ruled that one so lovely could not be guilty. Similarly down the ages certain advocates of the law have in varying degree resorted to this ruse in defense of women clients.

The noble and the ignoble have all made their bid for fame. Noteworthy among the ignoble who worked prodigiously and successfully in attaining fame was the charlatan Pietro Aretino,[4] of Arezzo, Italy (*ca.* the first half of the sixteenth century), who died while laughing uproariously at some obscene discourse. He was the bête noire of princes, for he wrote lengthy and scurrilous defamatory letters and pamphlets, which he circulated to their detriment. Instead of prosecuting him, they bribed him with money, gifts, and favors to forestall further slander. In addition to blackmail, Aretino wrote prolifically on both religious and obscene subjects. Among his best-known works is the *Ragionamenti,* containing, among other stories, the history of the traveling prostitute. From his considerable ill-gotten wealth he bought favors and even had coins struck with his image, bearing the appellation "The Divine Pietro Aretino," by which he was extensively known. Among his possessions he prized a gold chain given him by a prince, which treasure he was compelled reluctantly to part with, however, as a dowry for the hand of his ugly daughter. A classic portrait of Aretino in princely garb, with an elaborate gold chain, done by the famous artist Titian,[5] now hangs in the Palazzo Pitti in Florence.

Among the host of illegitimates who now hold first rank in history's hall of fame is James Smithson, who was on his mother's side related to kings and on his father's side to the Northumberlands, Percys, and royalty. His relatives of more formal birth held high their regal noses and ignored him, that they might not be soiled by contact with one born under the bar sinister. Their actions so hurt his sensitive soul that he wrote, "The best blood of England flows in my veins; on my father's side I am a Northumberland, . . . but this avails me nought. My name shall live in the memory of man when the titles of the Northumberlands and the Percys are extinct and forgotten." To this end he bequeathed half a million dollars to the young United States for the establishment of an institution for the worldwide collection and diffusion of knowledge. His trust, remarkable at that time, has been faithfully executed over the intervening years by the Smithsonian Institution.

Walter Raleigh, that indefatigable warrior, statesman, colonizer, author, poet, gallant, and one-time queen's favorite (finally beheaded), left to us numerous symbols of his fame both in history and in his writings. To mention one instance, let us consider the influence of his counseling Queen Elizabeth to name the English discovery in North America "Virginia"[6] in honor of her, if not technical, at least social, status. During his early days at court, as a young and renowned returned warrior, he, too, began his personal battle against oblivion and was fearful of the manner in which posterity would remember him. This may be inferred from the incident of his etching with a diamond on the glass pane of the palace window where the Queen might see:

> Feign would I climb
> But I fear to fall.

Under which, the Queen wrote with *her* diamond:

> If thy heart fail thee
> Climb not at all.

From the voluminous papers of James Boswell may yet come into print data whereby Samuel Johnson may be remembered most because Boswell was his biographer and not for his own contributions to literature. *Boswell's London Journal* (1762–63),[7] published in 1950, intimately revealing, and written in a vein similar to that of *Pepys' Diary,* mirrors himself and his associates, among whom he includes the Northumberlands and the Percys.[7]

Simón Bolívar,[8] the George Washington of Spanish America, labored heroically to free most of a continent from Spain and establish a free federated state. After a long and unsuccessful

struggle in pursuit of his cause, he said on his deathbed:

. . . los tres grandes majaderos de la historia, hemos sido Jesucristo, don Quijote y yo. ("The three greatest fools of history have been Jesus Christ, Don Quixote and I.") *Hemos arado en la mar.* ("We have plowed in the sea.")

Despite his final pessimism he has been appropriately memorialized by numerous equestrian statues in Argentina, Bolivia, Chile, and Venezuela. To Hispano-Americans he is the father of their liberty.

Fame's Fragile Page

Because of the ruthlessness of barbarous forces—the latest of which is the threat of the atomic and hydrogen bombs—and the ravages of time, the battle for survival of man's memorabilia, concrete or legendary, *versus* oblivion is individually eventually lost to oblivion. The poet Percy Bysshe Shelley summed up the fate of an imaginary illustrious individual in his sonnet *Ozymandias* thus:

I met a traveller from an antique land
Who said: Two vast and trunkless legs of stone
Stand in the desert. Near them, on the sand,
Half sunk, a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that the sculptor well those passions read
Which yet survive (stamped on these lifeless things),
The hand that mocked them and the heart that fed.
And on the pedestal these words appear:
"My name is Ozymandias, king of kings:
Look on my works, ye mighty and despair!"
Nothing beside remains. Round the decay
Of that colossal wreck, boundless and bare
The lone and level sands stretch far away.[9]

The Brahmanic point of view concerning man's lost estate is effectively expressed in the Mahabharata. We are told that an anchorite, who had "left the world" before marrying, came to a terrible place, which was in fact the pit of hell. There he recognized his father and his grandfather—the long series of all his ancestors suspended one below another along the open mouth of the abyss. The rope that prevented them from falling was slowly and surely being gnawed in two by a mouse, a figure representing Time. Many voices—some well known, reminding him of accents heard when a child, some unknown, yet appealing to a profound and hidden instinct—cried, "Save us! Save us!" The only hope for the long series of ancestors was for a son to be born of their descendant. The anchorite understood the lesson, married, and was able to save himself without remorse, having saved his ancestors.[10]

Some of the sons of man battle valiantly but eventually in vain against oblivion, and many millions of others, despite their desire to be known and remembered as individuals, do nothing to raise themselves above the inertia of mere existence. Many of the latter may never have heard:

Life is real! Life is earnest!
And the grave is not its goal;
Dust thou art, to dust returnest,
Was not spoken of the soul.

Although the memory of both illustrious and infamous individuals may eventually be lost to that all-devouring monster oblivion, we still firmly believe that man, like the brook, will go on forever. Although beaten down and lost in enormous numbers at times, he has always risen from his ashes like the fabulous phoenix, to carry out in his descendants the design of his creator.

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Our Taste Receptors

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MAN is said to possess five primary senses; vision, hearing, touch, smell, and taste. The two latter senses are thought to be the oldest in the evolution of man. It is by means of smell and taste that an animal perceives a change in his chemical environment. This is of utmost importance for lower animals, since a great deal of their behavior is related to the search for suitable food. Fish, for example, have chemoreceptors over much of the exterior surface of the body, which facilitates the detection of food in the surrounding water. In higher animals the specialized chemoreceptors are confined to particular regions, conveniently located so as to sample the intake of food. In man the gustatory receptors are confined to the oral cavity—in particular, the dorsal surface of the tongue—and the olfactory receptors are located in the upper nasal region. Thus it is possible to sample both the food ingested and its aroma. Because of the location of the chemoreceptors, it is often thought that both taste and smell are vitally related to man's nutrition. Many recent studies have indicated that this relationship is very real.

Although the importance of both gustation and olfaction has been recognized for many years, little is yet known as to how the chemoreceptors respond to a change in their chemical environment. There are two reasons for the lack of knowledge concerning the chemical senses as compared to those of vision or audition. First, the exact nature of the stimulus is not known, although it appears to be physicochemical. On the other hand, in vision the stimulus is the photon and in audition it is the change in air pressure. Second, it has been found to be more difficult to study the responses of the chemoreceptors with the usual physiological techniques that have been applied and found to be so rewarding in the study of the visual and auditory receptors. This is particularly true of the olfactory receptors.

The study of the sense of taste may be approached from one of two directions, the choice being dependent upon the questions one wishes answered. First, one may be concerned with the behavioral responses that are initiated when the chemoreceptors are chemically excited. In the past, such psychological factors constituted the major portion of all studies of taste. The studies were not limited to man alone—both lower vertebrate and invertebrate forms were investigated. These studies provided answers to many questions concerning the over-all behavioral response of an individual to various taste substances—answers which are of utmost importance to the economic welfare of man, for they deal with such topics as nutrition and the palatability of food.

The second approach concerns itself with a molecular explanation of the chemical excitation of the nervous system and the specific sensitivity of the chemoreceptors. This involves one of the most important biological problems of our time: the relationship of the structure of molecules to their physiological action. The taste end organs are ideally suited for such a study since they can respond to thousands of different substances under normal physiological conditions. In addition, the end organs relay their information to other parts of the nervous system in the form of electrical impulses and thus present opportunity for the experimenter to study the reactions of this system with quantitative methods not usually possible in other areas of biology. It is this approach that is to be discussed here.

Morphology of the Taste Receptors. The receptors associated with taste are usually found in the taste buds. These end organs are composed of two types of cells, one a supporting cell and the other believed to be the taste cell. Both types of cells are grouped together into a small budlike structure, the taste bud (Fig. 1). A narrow pas-

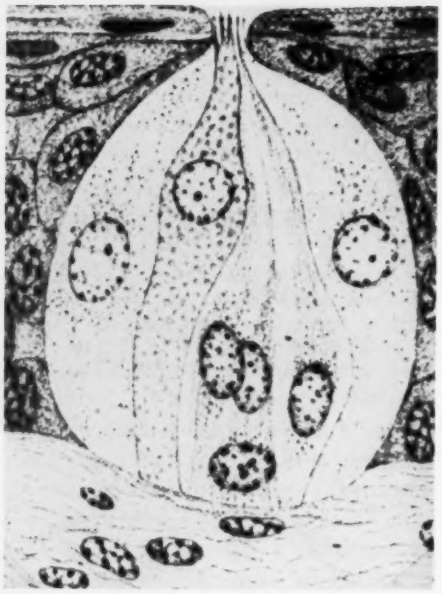


FIG. 1. Taste bud of the foliate papilla of a cat (after Lenhossek).

sage, the taste pore, connects the taste bud to the open surface of the tongue. Thin hairlike filaments project into the taste pore from the taste cells, and many believe that it is the filaments that are stimulated by the substances that are tasted. The taste bud is innervated by small nerves that arise from a subepithelial plexus, wind around the taste cells, and terminate in knoblike projections on the cell.

The taste buds are found primarily on the dorsal surface of the tongue, although they may be sparsely distributed over other structures of the oral cavity. On the tongue they are located in the trenches of the circumvallate papillae, the grooves of the foliate papillae, and above the dermal core of numerous fungiform papillae. The anterior two thirds of the tongue contains only fungiform papillae and is innervated by a portion of the lingual nerve. These taste fibers branch away from the lingual nerve to comprise the chorda tympani nerve, which then passes through the middle ear and joins the facial nerve. The posterior third of the tongue is innervated by the glossopharyngeal nerve. The vagus nerve may receive taste fibers from other portions of the oral cavity.

The end organs of taste are unusual in their close association with their nerve supply. Thus if one cuts the nerve, both the nerve and the taste buds it innervates degenerate. During the eventual regeneration of the nerve fibers, new taste buds are formed from the epithelial tissue of the tongue, so that ordinary epithelial tissue is transformed into specialized taste cells that are able to respond to dilute solutions of various kinds. How this transformation is accomplished is not known.

Although it has been shown that the taste end organs are functionally of different types, no anatomical differences among the taste buds of the tongue have been observed. Recently, however, the enzymes that are present in the taste buds and surrounding tissue have been studied. Histochemical preparations have revealed that esterase, hexose diphosphatase, yeast adenylase, acid phosphatase, lipase, muscle adenylase, and ribonuclease are all localized in gustatory regions of the tongue. These enzymes are located not only in the taste buds, but some are also localized in neighboring tissue. Selected substances that have well-defined tastes have been shown to affect one or more of the six enzyme activities. It is proposed by the investigators that the mechanism of taste stimulation involves the reaction of the taste substance with enzymes. If this be true, then the result of such histochemical studies on gustatory regions would be of fundamental importance to our understanding of the nature of the taste receptor.

Our present knowledge of the morphology of the cellular structures of taste contributes little to our understanding as to how a biological system can detect and differentiate a large number of chemical substances. It is possible to stimulate a single papilla of the human tongue and study the response, but each such papilla has a large number of taste buds, so that single taste bud stimulation has not been achieved. Fortunately, however, the rat usually has but one taste bud per fungiform papilla, and the papillae themselves are far enough apart so that single taste bud stimulation is possible. An experiment utilizing such stimulation must, however, rely upon the electrical recording of the response of the taste nerves innervating the taste bud, rather than classical psychological methods. Such an experiment would indicate the responses of a single taste bud, but is this organ the ultimate unit of taste, or is it the individual cell within the taste bud? This is but one of the fundamental questions that confront those interested in chemoreceptors.

Taste Modalities. It is commonly believed that there are four fundamental taste qualities, the salty, sour, bitter, and sweet, from which all other tastes can be derived. This is perhaps the most important of all the concepts upon which our present theories of taste are constructed. What evidence supports the concept of four taste modalities?

It was recognized very early that not all areas of the tongue responded to a given substance in the

same manner. For example, sweet tastes are perceived near the tip of the tongue, and bitter tastes near the back of the tongue. Scientific inquiry confirms the fact that the sweet sensitivity is greatest at the tip, the bitter at the back, the salt at the tip and sides, and the sour on the sides (Fig. 2). This would suggest that each of these regions possesses receptors that respond predominantly to compounds which elicit one of the four primary qualities.

Because the fungiform papillae of the human tongue are rather large, a single papilla can be stimulated with the aid of a fine brush containing any particular solution desired. In this manner the specificity of the taste buds associated with a papilla can be tested, using solutions of sucrose, quinine, sodium chloride, and hydrochloric acid. These four substances are often used as representative of those that elicit the pure sweet, bitter, salt, and sour tastes, respectively. Some papillae react only to sodium chloride, others only to hydrochloric acid, and others only to sucrose. The majority of papillae, however, respond to two or more of the four test solutions. Since a single human fungiform papilla has several taste buds associated with it, it has been suggested that the individual taste bud may respond specifically to one of the four types of stimuli, and that the number of stimuli that excite the taste buds of a single fungiform papilla is a result of the chance combination of the four types of taste buds.

If there are but four primary taste qualities, and if there are at least four substances that are able to elicit the pure taste representative of each quality, then it should be possible to duplicate the taste of any given substance by a suitable mixture of these four substances. Von Skramlik has succeeded in duplicating the mixed tastes of many inorganic salts in this manner and mathematically coding the mixed taste by quantities of each of the four substances comprising the mixtures.

The differential sensitivity of the four taste qualities to various drugs also supports the four modality theory. The juice of gymnema leaves applied to the surface of the tongue decreases the sweet and bitter sensitivities, whereas the salt and sour sensitivities remain unchanged. Cocaine applied to the tongue decreases all sensations normally arising from it. Pain, however, disappears first, and then bitter, sweet, saline, and sour sensations are eliminated, in that order; touch is the last to disappear. Whether such specificity is a direct result of the action of the drug on the taste cell itself or on the nerve fibers innervating it has not been ascertained. Electrophysiological studies show, however, that the bitter nerve fibers are much smaller in diameter than salt and sour fibers, and it has been established that such drugs interfere with nerve conduction in a manner that is dependent upon the nerve diameter.

FIG. 2. Diagram of the surface of the right half of a human tongue showing those areas most responsive to sour, salty, sweet, and bitter substances.

The most striking evidence in support of the four modality theory has been presented by Pfaffmann. Taste nerve strands containing a single active nerve fiber were dissected from the taste nerves innervating the tongue of the cat. The electrical activity was then recorded from the single fiber as various solutions were dropped on the surface of the tongue. Not all the nerve fibers tested responded in the same manner to a given number of solutions. Three different fiber groups were classified by Pfaffmann according to the solutions to which they responded. The first group consisted of the acid fibers, which responded to potassium chloride, acetic acid, and hydrochloric acid. The second group, the acid-salt fibers, responded to potassium chloride, sodium acetate, calcium chloride, hydrochloric acid, acetic acid, and sodium chloride. The third group, the acid-quinine fibers, responded to acetic acid, hydrochloric acid, and quinine. Of the salts, only sodium chloride, which gave no response, was tested on the third group. Saturated sucrose did not stimulate the fibers tested by Pfaffmann, although it has recently been demonstrated, using different electrophysiological techniques, that taste nerve activity in the cat can be recorded in response to sucrose, the threshold being under 0.25 *M*. It is concluded that the sour taste is mediated when all three fiber groups are stimulated simultaneously. Stimulation of the acid-salt fiber group alone would mediate a salt response, whereas the acid-quinine group would mediate a bitter response. The single nerve fiber experiments indicate that the four taste modalities are reflected peripherally to the presence of receptors that are somewhat specific to compounds associated with the modalities, but not exclusively sen-

sitive to compounds associated with any one modality.

Additional modalities are often postulated, especially those relating to the alkaline and metallic tastes, to serve as a basis for tastes not satisfactorily included in the classical four modality theory. It is also true that the good agreement between the experimental facts and the four modality theory may be a result of the limited number of chemicals used in the study, since four compounds are usually chosen, each of which is indicative of one of the four modalities. This theory is a result of but one of the first steps in our attempt to understand how the tongue can respond to thousands of different compounds producing different sensations. It is a useful theory, but an oversimplification of the complexities associated with taste phenomena.

Salty Taste. Sodium chloride, or common table salt, elicits a sensation designated as salty. Other salts applied to the human tongue produce tastes that are mixed. For example, potassium chloride has a definite bitter as well as salty taste. Not only does the taste depend upon the particular salt chosen, but it is also dependent upon the concentration of the salt. For this reason it is useful to study electrophysiologically the reaction of the chemoreceptors that respond to the salts and not to the bitter or sweet substances.

Records of the electrical nervous activity of the chorda tympani nerve of the rat have shown that it is the cation that has the predominant effect on the ability of the salt to stimulate the salt receptors. The anion has a lesser effect but is nonetheless important. No physical or chemical property of the salts has yet been found to be solely responsible for the ability of the salt to stimulate. However, it does appear that nonelectrolytes cannot stimulate the salt receptors.

Sour Taste. Almost all the substances that elicit a sour sensation contain an acid. For example, there is acetic acid in vinegar, citric acid in lemons, lactic acid in sour milk, and malic acid in apples. For this reason the sour taste has always been associated with acids and, therefore, with the hydrogen ion. Since the hydrogen ion is the only one all the acids have in common, one might assume that it is this hydrogen ion that is responsible for the stimulation of the acid receptors. However, human threshold concentrations for various acid solutions are not at equal pH. In fact, acetic acid evokes a much stronger sensation of sourness than does hydrochloric acid at the same pH. On the other hand, hydrochloric acid is a more powerful stimulus than is acetic acid at the same molar concentration. The lack of a simple correlation between the pH of a solution and the sour sensation for which it is responsible has disturbed those interested in taste for many years.

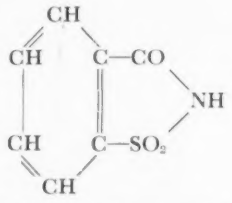
From these observations two different interpretations have evolved. First, it is known that saliva acts as a buffer and therefore reacts with any acid solution applied to the tongue, so that the available hydrogen ions decrease. If, however, a weak organic acid such as acetic acid is placed on the tongue, the buffering effect of the saliva is not as great, since the acetic acid tends to dissociate to produce more hydrogen ions if those already present react with the buffer. Thus the buffer effect of the saliva present on the tongue allows the solutions containing weakly dissociated organic acids to be more effective in stimulating the acid receptors than solutions of the same pH containing strong acids. Liljestrand found that buffer mixtures of acetic acid and sodium acetate could be prepared so that a sour threshold would be found at pH 5.6, whereas the threshold for acetic acid alone was pH 3.9. He concluded that the sour taste is due to the titratable acidity of the solution. It should be remembered, however, that Pfaffmann found a large number of single taste fibers that responded to both acid and salt stimulation of the tongue of the cat. It is therefore possible that the salt of the buffer mixture itself contributes to the threshold measured by Liljestrand.

The second interpretation assumes that the acids must enter the receptor cell and, therefore, pass through a lipid phase. Taylor has studied the taste thresholds of various acids and concludes that those weak acids that are more lipid-soluble are also the acids which elicit a sour sensation at a hydrogen ion concentration lower than the strong acids that are not appreciably lipid-soluble. One difficulty with this explanation is that acids usually enter cells rather slowly, whereas the sour receptors of the rat can respond to an acid solution well within 50 msec after the solution is applied to the tongue.

It can readily be seen that those interested in studies of taste are confronted with the same problem that disturbs biologists in other fields; i.e., there usually exists no simple correlation between the physical or chemical properties of a group of substances and the extent of the biological effects they produce on living cells.

Sweet Taste. The sweet taste is produced by a variety of un-ionized organic compounds, particularly by certain polyhydric alcohols. A few electrolytes such as the beryllium salts and the amino

acids may also taste sweet. The sugars are the most common molecules that are sweet to man. Since they usually are important as sources of food, many investigators regard the sweet taste as being closely associated with the nutrition of the animal. Several artificial sweeteners, however, have been found to elicit a sweet taste much more intense than any of the sugars of equal concentration. One substance, saccharin, is used generally as an artificial sweetener, but has no known nutritional value.



o—Sulfobenzimide (saccharin)

Bitter Taste. Whereas the sweet sensations are usually associated with nutritionally important foods, it is the bitter sensation that is associated with substances harmful to man. This statement is, of course, an overgeneralization of the known facts; nevertheless, a large number of alkaloids and glucosides are both distastefully bitter and poisonous. Among this group of substances are those said to stimulate man's sense of taste at unusually low concentrations. Quinine hydrochloride has been reported to elicit a bitter sensation at a concentration of 4×10^{-5} *M*. This threshold is one of the lowest of all those reported for taste but yet is not as low as some olfactory thresholds. For this reason the statement is often made that the olfactory receptors are much more sensitive to chemical stimuli than are the gustatory receptors.

Physiological Characteristics of the Taste Receptors. The measurement of threshold for a large variety of compounds is the most widespread method used in the study of taste. Threshold is usually determined as the least concentration of a substance necessary to elicit a reaction from an animal as measured by a well-defined behavioral response. Since most substances elicit a mixed sensation of taste, it is difficult to ascertain that the threshold measured by means of a behavioral response is also the threshold of a particular type of taste receptor. This is readily comprehended when one compares the taste of NaCl and KCl at different concentrations as reported by Skramlik (Table 1).

Thus, if one defines threshold as that concentration of a substance which can be detected as different from water, then KCl would have a lower threshold than NaCl. If, however, one defines threshold as the lowest concentration of a substance which can be identified to possess a salty taste, then NaCl would have a lower threshold than KCl. It is even more difficult to compare the thresholds measured by behavioral responses of animals other than man to the thresholds of a particular kind of taste receptor.

TABLE 1

Molar Concentration	Taste of NaCl	Taste of KCl
0.009	No taste	Sweet
.010	Slight sweet	Sweeter
.015	Sweeter	Still sweeter
.020	Sweet	Sweet, bitter
.030	Strong sweet	Bitter
.040	Salty sweet	Bitter
.050	Salty	Bitter, salty
.070	Saltier	" "
.100	Still saltier	" "
.200	Pure salty	Bitter, salty, sour
0.500	" "	" " "

The threshold value is but one point on the total curve relating response to concentration. The complete curve can be determined by measuring the magnitude of the electrical activity of the chorda tympani in response to the activation of a given group of receptors on the tongue by various concentrations of a substance (Fig. 3).

Note that a point is reached where a further increase in concentration would not result in an appreciable increase in response. This maximum value is called the saturation level. The measurement of response-concentration curves of a large number of salts reveals that each salt possesses a unique saturation level. Such data are important in the formulation of a theory of taste receptor stimulation, since the saturation levels indicate a dependence upon the physicochemical properties of the structure of the chemoreceptors that are directly involved in stimulation and not merely a dependence on the total number of molecules available to the receptor.

The taste receptors of the tongue respond very rapidly. Several investigators have measured the interval between the application of a salt or acid stimulus and the resulting activity as recorded from the taste nerve of the rat and found a latency of the order of 50 msec.

The receptors show an initial adaptation during the first two seconds of response (Fig. 4). They do not adapt completely, however, but reach a steady level of response that may be maintained for many minutes during continued salt stimulation. When the chemical is washed from the tongue with water, the response declines rapidly at a rate characteristic for each substance.

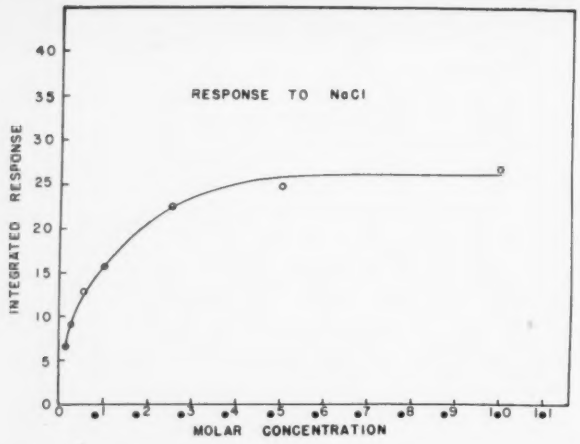


FIG. 3. Curve showing the electrical activity of the taste nerve (integrated response) as various concentrations of sodium chloride solutions are flowed over the tongue of the rat.

Species Differences in Taste. Taste experiments have been performed on many types of animals, both vertebrates and invertebrates. The question then arises, are there differences in taste among various animals, and if so, to what extent? This question is difficult to answer because the behavioral criteria of response are dependent upon the type of animal chosen. A partial answer is given by electrophysiological studies of the taste nerve activity of several mammals.

The electrical activity of the chorda tympani nerve was measured as various solutions were applied to the tongue. Large variations in the response to a number of substances were found among the rat, guinea pig, cat, dog, hamster, and rabbit. For example, the hamster responded very well to low concentrations of various sugars, whereas the cat or dog responded rather poorly. The response to quinine was always rather poor, with the exception of the cat. The most noticeable variation was found in the ability of the various animals to respond to a given series of inorganic chloride salts. For example, the rat, guinea pig,

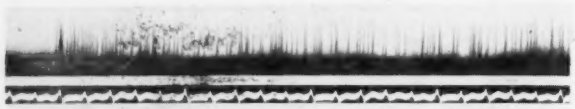
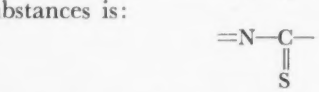


FIG. 4. The electrical activity of a single fiber of the chorda tympani nerve of the rat in response to 0.75 *M* NH_4Cl applied to the tongue. Time scale: 1 interval = 0.2 second.

and hamster all responded to a greater extent to NaCl than to KCl at the same molar concentration. The exact reverse was found to be true with the cat, dog, and rabbit. The above observations lead one to conclude that there are indeed variations in ability of the animals to respond to certain chemical substances.

Genetic Differences in Taste. It has been demonstrated that phenylthiourea (PTC) tastes bitter to some people and is tasteless to others. About 30 per cent of Americans do not perceive the bitter taste of dilute solutions of PTC. Furthermore, the lack of sensitivity to PTC in this group of people (nontasters) is inherited according to simple Mendelian laws. This differential taste sensitivity is not common to all bitter substances; it is not found with quinine, urea, strychnine, etc. There are, however, substances closely related to PTC which behave in a similar manner. It is assumed that the differences presented by these substances are determined by the same genetic factors that control the taste differences with PTC.

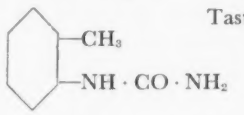
Equally important is the fact that the reactions which occur with these substances are chemically specific. The chemical group common to all these substances is:



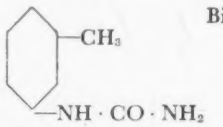
The presence of this group in the structure of a molecule is itself a necessary criterion in determining whether it produces a differential taste sensitivity similar to PTC. It recently has been shown that it is also common to a large number of antithyroid substances.

Chemical Specificity is a common occurrence in biological phenomena, and it is therefore not surprising to find that taste is quite dependent upon the chemical structure of the stimulating substances, including the orientation of the substituent groups of the molecule. For example:

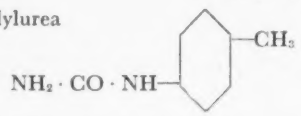
o-Tolylurea — Tasteless



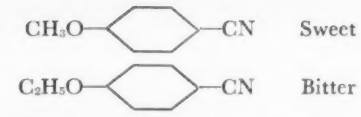
m-Tolylurea — Bitter



p-Tolylurea — Sweetish



A slight change in one part of a molecule may also change the taste:



Stereoisomers may also have different tastes. Dextrorotatory asparagine is reported to be sweet, whereas levorotatory asparagine is tasteless. These observations suggest that both sweet and bitter substances may react with specific molecules located in the taste end organ and that the reaction is dependent upon the configuration and orientation of all the molecules involved.

Theories of Taste Stimulation. Theories as to the mechanism involved in the stimulation of the taste receptors have been proposed by many speculators. Since scant factual information concerning the chemoreceptors themselves is available, the theories offer little that is concrete. Any theory, to be valid, must account for several well-defined facts:

1. The taste receptors respond rapidly to a chemical stimulus.
2. All substances to be tasted must be in a liquid state.
3. A large variety of substances will stimulate the taste receptors.
4. The concentrations of the chemical stimulants for threshold excitation are seldom very large.
5. Many of the substances applied to the surface of the tongue are usually classified as nonphysiological. For example, 1.0 *M* NaCN, 10 mM strychnine and acids of pH 2.5, all have been demonstrated to stimulate taste receptors without resulting in rapid deterioration of the receptor cells themselves.
6. The taste receptor rapidly elicits a steady level of response, the magnitude of which is a function of the concentration of the applied substance.
7. The response to many substances remains constant over a long period of stimulation.
8. Receptor stimulation must be followed by the electrical depolarization of the nerve membrane and possibly preceded by the depolarization of the end organ itself.
9. The taste response declines rapidly with a water rinse.
10. Chemical specificity is a property of the receptors.
11. There are genetic variations in the taste ability of humans.

Two prevalent theories of taste stimulation that are able to account for many but not all of the properties of the receptors are worthy of note. The first theory maintains that the taste substances participate in an adsorption process, possibly with proteins, at the surface of the receptor. As a direct result of this, there is a rapid depolarization of the receptor surface which spreads to the attached nerve fiber and excites it. The second theory postulates that the taste substances enter the receptor cell and interact with enzymatic processes. These chemical events are in turn related to the eventual depolarization of the associated nerve fiber. Both these theories are broad enough so that definite proof or disproof is difficult. They are similar in that they both rely upon adsorption to account for the properties of chemical specificity, and both rely upon changes in cellular protein structure to explain genetic phenomena. They differ in that the enzymatic theory supposes that the taste substances enter the receptor cell and that the same substances, or possible end products of a chemical reaction, must also leave the cell. This must all be performed very rapidly and with a large variety of substances, some of which are very toxic even in low concentrations.

Many variations of these two general theories have been proposed. In fact, there is no reason to assume that there is but one type of stimulating mechanism for all types of taste substances. This is especially noteworthy when one considers that the sour and salty tastes are always elicited by electrolytes and never by nonelectrolytes, whereas the substances eliciting the bitter or sweet taste may be either electrolytes or nonelectrolytes. At present, most theories basically assume that there are four types of receptors corresponding to the four modalities. An understanding of the mechanism of receptor stimulation is but one step toward a complete understanding of taste phenomena. How the nerve messages, which are evoked by the chemical stimuli applied to the tongue, are translated into a sensation of taste is little understood.

Creative Thought in Scientific Research

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THE quality of research may vary through a wide range. Low on the quality scale are the quantity-oriented researches done with but little creative thought, as described by Horowitz,[1] and the "useless research of which there will always be aplenty," as characterized by Millikan.[2] Heading the list are some epochal masterpieces that have diverted large branches of the stream of human thought and technological activity into new channels. The difference between sterility and brilliance results from the inspiration of the worker, his judgment, his energy, and his capacity for creativity and originality.

It is possible that these characteristics can be developed, particularly creative capacity, and that the quality of research may thereby be improved. The fact that this paper has been written is an expression of my own firm conviction that this can be done. Guilford[3] supported this view in a presidential address before the American Psychological Association, stating his opinion that much can be done to encourage the development of creativity.

In pursuit of this aim, the first step necessarily is to explore the creative process itself and its relation to research. Only then does it become possible to attack the twin problems of avoiding the mistakes that arise from misconceptions and of formulating positive guide lines and testing their effectiveness. This paper presents the conclusions drawn from a limited survey of the literature on creativity. The reader should be warned that a study of the subject leads to much that is in the field of "nonlogical" thinking (which is quite different from "illogical" or "irrational" thought), hence he should be prepared to consider seriously such matters as "insight" and "intuition" and their relation to research.

Since research takes place in the human mind, its technical aspects are clearly within the province of the psychologist. Inquiry among psychologists, however, brings out the fact that they have only recently begun to study creativity intensively. Statistics cited by Guilford[3] indicate that psychological research in this field has been largely neglected, but at least three books by psychologists are well worth mention. Hutchinson[4] has examined creative thinking in general and has outlined its psychological phases in considerable detail. Wertheimer[5] has examined the thought patterns of individuals ranging from school children to Galileo and Einstein and has analyzed them from the Gestalt viewpoint, as well as from the standpoint of classical logic. In the field of invention Rossman[6] has contributed a valuable, if somewhat subjective, psychological study.

One might hope that scientists and engineers who do creative work would contribute more extensively to the literature on this subject, but their traditional training concentrates heavily on science and its application to technical problems, and their psychological orientation toward research is generally accomplished by association with their teachers and colleagues. Consequently they seldom examine emotional patterns and thought processes objectively enough to make them subjects for publication. Some valuable works have appeared, however, including a group of papers on creativity in engineering[7] and a book by Beveridge.[8] In the latter, an experienced researcher analyzes the psychological and sociological factors involved in research activity. Freedman[9] presents some valuable studies of research and researches from the historical viewpoint, but with limited consideration of the nonlogical and intuitive aspects of research. Hertz[10] describes the practice of research

in somewhat the same way, although with more emphasis on the administrative aspects; and both develop, and to some degree classify, the methods of research for the benefit of students and beginners. Killeffer[11] uses the case history approach to an even greater degree, but to the same primary end of setting forth tactical methods of work.

Administrators who are responsible for group or team research are publishing a small but expanding segment of the literature, which might be characterized as the "Management of Scientific Research." A short paper by Anthony[12] under this title discusses sources of information in this field, and his more recent book[13] surveys the field in general. Here the tendency is to become preoccupied with the problems of program formulation, preparation of budgets, design of facilities, and other procedural matters of management, with only minor consideration of the researcher's mind as the source of research productivity. Two books that might be classed with the "popular-inspirational" flood of printed words are worthy of mention in this connection, even though the parts of them that are directly applicable to research are diluted with much other material. They are by Flesch[14] and by Osborn,[15] who presents most clearly and convincingly the thesis that one can and should develop creativity in all one's daily activities.

The Creative Process

In the following discussion, various aspects of creativity are considered separately, as though they were discrete steps in a serial process. Actually these aspects may merge, vary in importance or in chronological order, or proceed as cycles within cycles. In the effort to examine some of the microstructure of the growth processes of science and technology, each simplification for the purpose of clarity must exclude consideration of many complicated interactions.

From the standpoint of the psychologist there appears to be much in common among the creative activities of scientists, engineers, inventors, writers, artists, musicians, organizers of industry, and others who enrich our culture by their original contributions, but we shall pay little attention to creation outside the field of science. Here creativity may appear to consist only in finding the answers to previously unsolved problems, as implied by Freedman[9] and Hertz,[10] but in its broader sense it must also include the search for, and the definition and evaluation of, problems. In the arts creativity is much less a matter of problem-solving than it is a matter of envisioning the general nature of the ultimate creation and then laboriously bringing it into being by filling in the structure with consonant detail. Rossman[6] characterizes invention as a process of making new combinations of ideas derived from the prior art, and he states that the first and most essential step in this process is the clear recognition of a new, latent, or incompletely satisfied need or difficulty.

Motivation

Whatever names the psychologist may apply to the factors involved, some inner driving force must be present from the beginning of the creative process. The primal drives for food, family, and fame may aid and abet certain proximate ones, such as the need to understand the hidden structure of things, so ably brought out and substantiated in detail by Wertheimer.[5] The research scientist is often said to be spurred on by "curiosity," the inventor by "laziness," and the industrial organizer by "ambition," but the common element here seems to be an urge to exercise whatever creative talents the individual may possess—the desire to respond to the challenge of the situation.

Enhancement of individual motivation is often possible if the individual consciously identifies himself as an innovator and adapts his behavior accordingly. One of the principal adaptations required appears to be the cultivation of an attitude of humility in the presence of nature. This attitude is implied by Kettering's[7] motto, "The Job is the Boss," whereas its antithesis is embodied in the old epigram that "an advisory capacity is the only capacity in which some people are willing to serve the Lord." In group action motivation may be increased by mutual stimulation among innovators, where the atmosphere becomes charged with the feeling of change and progress. Conversely, it seems possible to discourage motivation by conditioning the individual to refrain from questioning authority, convention, and tradition and, in groups, by excessively authoritarian leadership. Motivation, then, is dissatisfaction with some part of one's environment, coupled with the desire to do something to improve it.

Discovery of the Problem

In the creative process the problem may be discrete and identifiable, as, for instance, in the case of an inexplicable meter reading, or it may range the full gamut of indefiniteness to the point where it constitutes an urgent but perplexing search for the specific factor that is defective in the environ-

ment. In such a case the successful identification of the problem may be an act of creative thinking in and of itself, for change in the direction and momentum of current thought is most difficult where the need for the change has not been anticipated. In Chapters 6 and 7 of his autobiography Millikan[2] graphically describes his early struggles in establishing his main research problem or, as he puts it, in "trying to strike a productive lead."

In this phase enhancement of productivity may thus be largely a matter of developing greater audacity of imagination, breadth of viewpoint, and capacity for identification and rejection of the inconsequential in the establishment of individual or group objectives. Free interchange of information but with careful examination of all opinions, study of the literature to search out facts but with reluctant acceptance of conclusions, and careful thought directed toward reaching the core of each problem encountered are called for at this stage. Complete familiarity with the conventional thinking in the field may be unnecessary, and there are those who maintain that it may actually be detrimental. Many new fields of research have been opened up by workers trained in two or more apparently unrelated disciplines. Tentative problems and objectives may be defined and examined as to the value that might be expected to accrue if their solutions were found, and in this way inconsequential problems may be rejected and less consequential ones may be laid aside in favor of those most crucial and worthy of effort in solution. Formal logic and mathematics seem to be of little aid here, except in the solution of subsidiary problems; instead, intuitive decisions must be made, always in the direction of greatest significance.

Search for the Solution

Having defined a problem, the researcher will proceed toward its solution by successive trials of various methods. The ordinary and usual methods will be tried first and may be found to be effective, in which case the research may evolve novel and valuable results with the exercise of only ordinary technical skill, and with no marked creativity in the accomplishment of this phase. Freedman,[9] Hertz,[10] and Killeffer[11] develop and classify what might be termed the "standard methods" of research.

Failing to find a solution by ordinary means, the highly motivated, persistent, and creative investigator may be expected to extend his efforts in a search for unusual tools and methods for the attack on the problem. Infrequently used mathematics, or experimental techniques borrowed from other fields of science, may provide the answer, and in some cases a long-forgotten idea found in the history of the field may be the requisite element. Breadth and depth of training and experience of the individual are clearly of value here, and in the case of team research the sum total of the experience of its members may be brought to bear upon a refractory problem. True creativity may be evident in the solutions to problems achieved by extraordinary means, or may result from the unusual resources of an individual or of a team.

When ordinary and extraordinary methods of solving the problem have been exhausted without success and the investigator still retains a high degree of motivation, there will follow a period of fruitless search for additional leads and clues. Discouragement and frustration are normal in this stage of the process, and less well-balanced individuals may develop neurotic and psychopathic symptoms as a result. The worker who has reached the stage where he has unsuccessfully tried all probable, possible, and remotely conceivable avenues toward a solution should then admit that he has been fairly beaten and should consciously lay the problem aside and relax. Such an admission of defeat will be difficult, and more so the greater the degree of motivation toward finding the solution; but the step should be taken nevertheless, for it appears to be necessary if the creative thought process is to continue. Hutchinson[4] discusses the psychology of this phase at some length.

Creative Insight

The achievement of creative insight that leads to the solution of a problem that was previously found to be completely refractory cannot be guaranteed, but many of the major and minor advances in science and the arts have evolved in this way, and in consequence its existence should not be ignored.

Preparation for the flash of insight appears to require all the elements previously outlined: motivation, definition of the problem, search for the solution, frustration, and relaxation; and it may require repetition of one or more parts of the cycle, or even the whole cycle. The time when insight will be achieved is generally unpredictable, although it appears to occur most often while the worker is in a state of mental relaxation, and each individual may find a situation which for him is most productive. Brilliant insight occurring as a dream has been recorded but is so dramatic that its importance may be overrated. The periods just

after waking in the morning, while shaving or bathing, while walking or riding in a public conveyance, or while at a concert or lecture seem to be productive for the majority of people reporting such experiences.

The flash of insight is generally accompanied by a feeling of elation, and in a surprisingly large number of cases the conception itself is not a simple one but is rather a visualization of a solution that is comparable in complexity to the problem itself. In the period immediately following, the individual often finds that subsidiary and supporting ideas come tumbling into consciousness, and the basic concept is often filled in with lesser detail in a remarkably short space of time. It is said that Einstein, in developing his special theory of relativity, labored with the problem for seven years before grasping the final integrating insight. Then he was able to put the theory into finished form in only five weeks. Capturing the insight at this stage is desirable, either by an effort of memory, written record, or other device, as there is a possibility that it may be lost in part, or even *in toto,* if this is not done.

Verification

Not all the concepts that are born during a flash of insight or that evolve during the period of intense activity that often occurs while the insight is being filled in with detail are found to be fully valid when viewed dispassionately. In certain creative fields it may be possible to skip the stage of verification, and some writers are reputed to avoid rewriting a manuscript for fear that the repairs of revision may be weaker than the flaws that they are intended to remedy.

In scientific research and engineering development it is essential to subject every idea or solution to careful and critical scrutiny to be sure that it is valid, adequate, and complete. The author of the idea should realize that his critical faculties and viewpoint will be biased in favor of the new idea or solution during the period of elation at finding it, and during the period when the thought processes that accompanied finding it are still vivid. Consequently, there is normally a considerable improvement in the critical faculty after the passage of time and after the intervention of other work. Conversely, there may develop in the individual a feeling of disappointment with, or even revulsion from, the idea when its inadequacies begin to become evident, and this results in unjustifiably severe self-criticism, or even unwarranted rejection. Criticism and evaluation of the idea by others may assist the innovator materially in reaching sound conclusions concerning the virtues and faults of his brain child.

Exploitation

Following the production of an item of creative thought, whether or not it withstands critical review by its originator, it is generally profitable to analyze its implications in relation to matters other than the original question it was intended to answer. In some cases the by-product values may greatly exceed the direct value of the product. Serendipity in research is worthy of careful cultivation, and even a concept that is demonstrably erroneous may prove to be the starting point of a line of thought leading to other conclusions that are valid and valuable. Perkin failed in his attempt to synthesize quinine, but in doing so he produced the first synthetic dye.

In the presentation of the new concept to others the innovator should clearly realize the probability that it will meet with resistance, and that the intensity of this resistance will be in proportion to the novelty and potential significance of the new concept. Insofar as science is a search for truth, it is at the same time a displacement of error, and the error is generally regarded as the truth because of its acceptance by authority and by the majority of workers in the field. Beveridge[8] devotes a chapter entitled "Difficulties" to the opposition encountered by scientists when innovations were proposed. Some individuals (and some organizations) cannot tolerate an externally generated idea in a field in which they consider themselves to be preeminent, and some administrators and groups tend to brand the innovator as "undependable." The presentation of the new idea must therefore be planned to overcome resistance by whatever means are available and necessary to meet any situation. Tact and understanding, persistence, and clarity of exposition will all be included in the successful strategy. Dexter[16] has some wise and pointed words along this line for the benefit of innovators in any field.

Synthesis

The process of creative thought has thus far been discussed as though it consisted of a series of discrete steps. Others have classified the subject differently—for instance, Le Chatelier,[7] who discusses creativity under the headings of *activity, imagination, judgment,* and *recorded knowledge.* Actually, each worker will follow a method suited to his own personality, training, and capabilities, and one investigator will make far greater use of one or

another of the steps in the process than another. One researcher may depend heavily upon reason and logic, and may have noteworthy success in straightforward search for the solution of problems, whereas another may be an introspective dreamer and may depend primarily upon insight. The nature of the field and the type of problem also govern the relative emphasis necessary at different stages in the process.

The inherent nature of science and technology is such that a major accomplishment may be likened more to a cathedral than to a single arch, in that the complexity of the cathedral requires the construction of many arches and the assembly and organization of much supporting material. Unlike the cathedral, however, it cannot be planned in advance, and the need for the second arch may not be visualized until the role and construction of the first have been clearly seen. Thus investigation proceeds in interlocking cycles, often with one accomplishment standing useless until a subsequent one complements it, or with several in process at the same time, each taking shape in conformity with the others.

The foregoing discussion will be of value only if it assists us in arriving at decisions relative to our own working methods and attitudes. The most important of these by far, in my opinion, are the decision to endeavor to work creatively despite frustrations, failures, and rebuffs; the recognition of the need for intensive search and for the imagination to find clarity of thought, and judgment to define the problems of greatest importance; and the resolution to take time to think in an atmosphere as free of distraction as possible.

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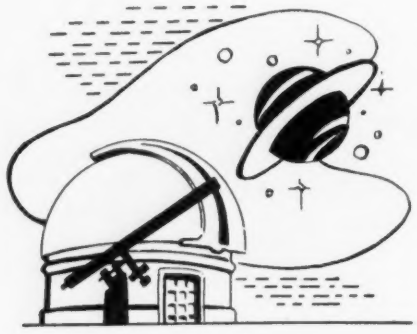

Somatomancy—Precursor of the Science of Human Constitution

WILLIAM A. LESSA

The author is a social anthropologist with an early background in anthropobiology. He combines his current work in supernaturalism with a long-standing interest in human constitution dating back to a period as research associate with the Columbia–Presbyterian Medical Center of New York. Professor Lessa has published several articles on constitution and is engaged in writing a history of work in this field. He is a graduate of Harvard and the University of Chicago, and is now teaching at the University of California at Los Angeles. At present he is secretary of the American Anthropological Association, AAAS affiliate.

FROM ancient times to the present, man has attempted to tear aside the veil that hides the unknown. In the days before there was any reliable body of science, his efforts to know himself and the world about him took forms which today seem both naïve and fantastic. In some instances, these bizarre pseudo sciences contained a germ of truth—a germ that was later to find new growth in a legitimate scientific field. Such an instance is offered by the pseudo sciences of somatomancy, a new term hereby proposed for all kinds of divination from the human body, whether involving phrenology, chiromancy, or various forms of astral physiognomy.* Although these once-flourishing arts have long since fallen into complete charlatanry and in some cases into oblivion, they were nevertheless among the forerunners of the modern science of human constitution, or "biotypology," as it is sometimes called.

Yet somatomancy has gone virtually unrecognized as a special and important effort on the part of man to pry loose the secrets of nature pertaining to his destiny and inner being. It deserves study along with its sister-forms of divination, such as pyromancy, divination by flames; lithomancy, divination by stones; and hydromancy, divination by water. It must be made clear at the outset, however, that this discussion is not intended to demonstrate that human constitution is a form of divination. Biotypology is a branch of legitimate science; somatomancy is a form of supernaturalism. But, just as parallels can be drawn between magic and science (without, however, the mistaken equating of one with the other which Frazer ascribed to primitives), so can certain analogies be seen between somatomancy and biotypology.

An interesting thing about somatomancy is that it is absent among primitive peoples, being found only among higher cultures, in which it has a long history. This may seem curious upon first consideration, but there appear to be good reasons, implicit in the social and psychological factors involved in somatomancy, for this anomaly.

There are two main types of body divination. The first may be called *astral somatomancy*; it is more mystical, divinatory, and supernaturally oriented than the second type, termed *natural somatomancy*. The logic behind astral somatomancy establishes a linkage between body features and astrology. Astrologers believe, of course, that earth and sky are intimately related, and that the celestial governs the terrestrial. The pertinence of this doctrine to physiognomy (the art of discovering mental and moral characteristics from physical appearance) is that sidereal physiognomists maintain that every man is marked by signs which reveal his destiny, temperament, and character. This approach has many manifestations, a unique one of which is that man is merely the universe in miniature. All things contained in the universe, or macrocosm, are correspondingly represented in man, the microcosm. Saunders, the author of the first work in English (1653) on neomancy (divination

* The obvious term, "anthropomancy," is unavailable because of its well-established and limited meaning of "divination from entrails of a human being."

FIG. 1. Body astrophysiognomy. The relation of the body to the signs of the zodiac. (Fludd, *Microcosmi Historia* [1619].)

from moles on the body), advanced an extensive argument to show that the position of markings on an individual has a bearing on the individual's relationship to the universe. Speaking of such markings, Saunders said, "It is a certain thing that every Humane Creature when it is born hath in some part of the body the mark of the Sign or Planet that governed at the hour and minute of their Conception and Nativity, which marks are in the parts of the body which are referred to those signs and Planets."

Astral physiognomy has many departments, depending upon the part of the body used in divination. Sometimes the whole body is correlated, part by part, with the stars (Fig. 1). Oftentimes it is the face that is scrutinized by the astral method (Fig. 2). But the most popular form of astral somatomancy is divination from the palm, or chiromancy. Here it is chiefly the lines and the seven "mounts" of the palm that are studied. The mounts are the small protuberances at the base of the fingers and thumb and along the outer edge of the palm (Fig. 3), and the characteristics of the individual are discerned from the degree to which these mounts are developed. The method of assigning characteristics to the individual mounts offers a fascinating example of an anthropomorphic circle employed generally in astral somatomancy. Originally certain human characteristics were ascribed to various Greek and Roman gods. Later, these characteristics were transferred to the planets named for those gods. Later still, the characteristics found their way into general astrological doctrine and, finally, by adoption, back to man himself by being assigned to specific parts of the human body, such as bumps on the palm (Fig. 4).

Thus, by this circuitous path, the mount of Jupiter at the base of the index finger indicates religion, ambition, love of honor, and felicity. Should this mount be very highly developed, it indicates an excess of the qualities represented—i.e., superstition, pride, and a tendency toward madness. If the mount is very weak or absent, the qualities suffer accordingly, becoming irreligion, shyness, sadness, and the lack of dignity. The other mounts are similarly read for their supposed significance.

Since the lines in the palm are not ordinarily linked with the stars, this part of chiromancy is not strictly astral. There are four principal lines—heart, life, head, and fortune. If they are deep and continuous, they indicate strength of the aspect with which they are involved; whereas if they are weak or broken, they are usually unfavorable.

In chiromancy, character divination of the individual is mixed with prophecy of his future prospects (Fig. 5), although some modern practitioners attempt to give the art a more "scientific" flavor by emphasizing the hand as a mirror of the traits of the individual rather than as a key to his fate.

In another form of astral somatomancy, metoposcopy, the lines of the forehead are studied in a manner analogous to the lines of the palm. Metoposcopy is of far greater recency than chiromancy, having been invented in the Renaissance, whereas

FIG. 2. Facial astrophysiognomy. The relation of the face to the planets. (Belot, *Oeuvres* [1654].)

chiromancy is at least 5000 years old in China, where the reading of the feet, or pedomancy, was also practiced. The founder of metoposcopy was Cardano, a famous and controversial Italian mathematician, philosopher, and physician. He mapped out the forehead into various regions, with each zone denoting a planet (Fig. 6). (As if in anticipation of modern basal metabolism technique, he decreed that the forehead must be examined in the morning before the subject had had breakfast.)

Mention has already been made of neomancy, or divination by moles. According to one convenient doctrine of this art, body moles are duplicated in the face according to their position on the body (Fig. 7), making it unnecessary for the neomancer to examine the body *in toto* and thus avoiding embarrassment to the client. We see here an example

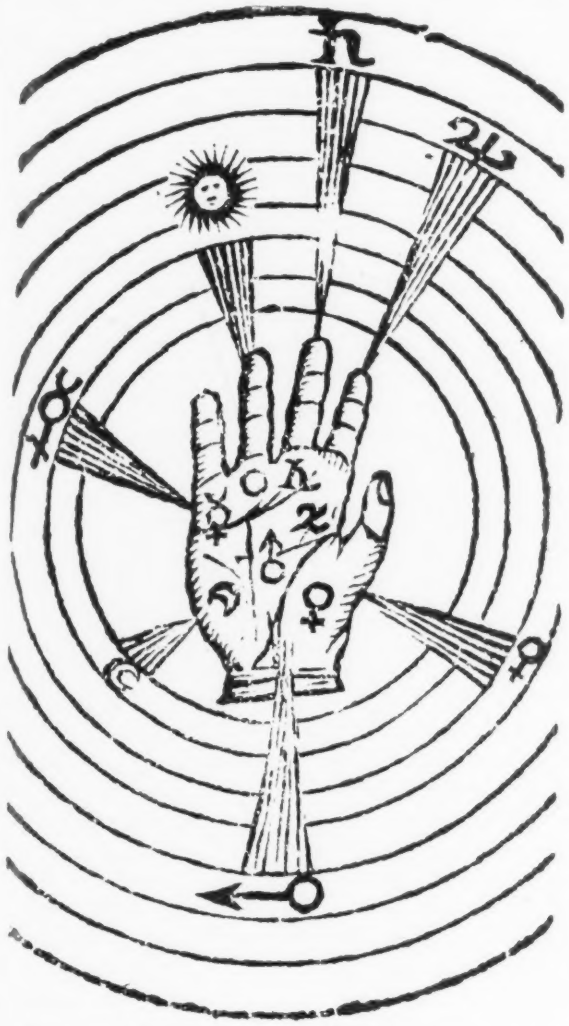

FIG. 3. Chiromancy. The relation of the palm to the planets. (Sicler, *La Chiromance Royale et Nouvelle* [1666].)

FIG. 4. A pictorial representation of the mythological indications to be found in the hand. (Cerchiari, *Chiromanzia e Tatuaggio* [1903].)

of the fact that, although body-diviners frequently view the body in terms of its discrete parts, each part is not necessarily studied as if it were a self-contained system, but is correlated with other parts. Of this we shall say more later.

If space permitted it could be shown that practically every external part of the body has been studied by astral physiognomists, but perhaps it will be sufficient to name two more: ophthalmoscopy, which divines from the eyes, and onychomancy, which divines from the fingernails.

The second grand division of somatomancy, called natural physiognomy, makes no use of astrology. It is not particularly occult nor unduly mysterious. However, it is unquestionably divinatory, differing from astral somatomancy chiefly in its emphasis on uncovering the secrets of mental and moral character rather than in predicting the course of events affecting the individual. Natural physiognomy is of course of great antiquity, some evidences of it being found in the Bible.

The earliest workers in systematic natural physiognomy labored to show that within the human

FIG. 5. Fate and the palm. An illustration from the earliest printed book on somatomancy. (Hartlieb, *Die Kunst Chiromantia* [1448].)

body there are signs indicative of a "sympathy" with other animals. Because the qualities of animals are easily understood (so the reasoning went), it is easy to assess the obscure inner nature of individual men by seeking the animal signs which mark them. The name theriologic physiognomy is given to divination employing such comparisons with animals. This was the favorite approach of the ancient Greeks, and it later received elaboration at the hands of Della Porta, the most honored of all natural physiognomists of the Renaissance (Figs. 8 and 9).

In Della Porta's chief work on the subject, published in 1569, he attempted to reduce the variations in man's facial features to the same sort of differences as those found in the animal kingdom. He then correlated these differences with the kinds of behavior thought to be characteristic of each animal. A small-headed man, he believed, is like an ostrich and very often acts like this bird. A man with the face of a lion is courageous, and one with the features of an ass is stupid, and so on. It is interesting to note that here again we have anthropomorphism turned back upon itself, with the qualities traditionally bestowed by man upon animals reapplied to man himself in terms of animal features.

Another and altogether different kind of premise is sometimes employed in natural physiognomy. It is the concept which in recent years has been called the doctrine of the *homme moyen*, or average man, and was much developed by the great Belgian mathematician and astronomer Quetelet. Without going into a description of the modern version of the premise, we can say that its basic tenet is the belief in an ideal: the mental-moral-aesthetic man who is what he is because he manifests the least deviation from the "average" in the population. Individuals who depart from this ideal are, in proportion to their deviation, inferior in mentality, morality, and appearance.

A third type of logical approach may be termed the pseudo-inductive method. Mantegazza has spoken derisively of it in the following words: "A woman with a dimple in her chin has been found to be an angel, and hence it is concluded that all who have this dear dimple must be well-intentioned people." This method, which may also be called the single-case method, was used extensively in the more recent works on physiognomonical endeavor. One of the disciples of Franz Joseph Gall, founder of phrenology, told how Gall had found the brain's "area of caution." He had chanced to stand behind two Viennese noted for their inability to make up their minds. Noting that both had heads which were rather narrow in a certain dimension, Gall at once decided that he had found the secret.

The fourth and final approach in natural physiognomy has no logical basis at all and may be termed the intuitive method. It is assumed by the physiognomist that because of a quasi-mystical power he is able automatically to divine the secrets of nature by scrutinizing the physiognomy of a man. This technique is employed by all the ama-

teur character readers in the world, who can "size up a man the minute I see him." Perhaps this method, unformulated as it may be, is much older than the theriologic approach used by Aristotle, Zophirus, Hippocrates, and other men of the ancient world. But few physiognomists would admit that they relied upon it, even though in some ways it has less to condemn it than many of the more sophisticated approaches used in astral and natural physiognomy.

The varieties of natural physiognomy are rather like those of astral physiognomy, depending on what part of the body is studied. Generally, it refers to the face alone, and in modern usage the term physiognomy is synonymous with the face. Sometimes various parts of the body are examined, as in astral somatomancy; and at times the terminology is the same as in the astral version. Occasionally, to avoid astronomical connotations, the natural physiognomists use or coin special expressions, such as D'Arpentigny did when he spoke of "chirognomy," the natural physiognomy of the hands, as distinct from chiromancy, which had been practically taken over by astrophysiognomists. In a similar way, "nevology" has been used to avoid the astrological implications of neomancy, although it, too, uses moles and birthmarks for interpretation.

FIG. 6. Metoposcopy. The relation of the forehead to the planets. (Cardano, *Metoposcopia* [1658].)

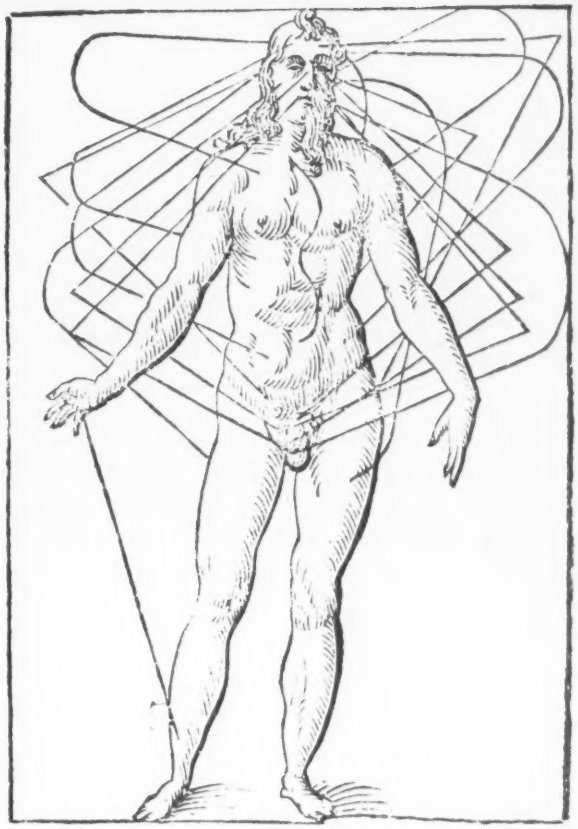

FIG. 7. Functional interrelationships. An early drawing showing the localities on the body that correspond to the localities of the face where moles are found. The figure is gynandromorphic. (Della Porta, *Della Fisonomia dell' Huomo* [1615].)

Natural ophthalmoscopy finds a champion in Fuchsius, who in 1615 issued a guide to what may be discovered by looking into eyes. Large pupils, he said, denote madness and incapacity. Small pupils, when they shine in the eye, betray a man who is wily, cunning, perverse, and libidinous. If the orbits move in an unequal circuit, it is a sign of a soul capable of horrible deeds. Other characteristics are assigned according to the size of the eyes, the color of the iris, and other details.

John Caspar Lavater, an eighteenth-century minister, demonstrated in his principal treatise an interest in warts. He suggested, for example, that women with brown hairy warts on the chin were industrious but "amorous to folly, or even to frenzy." He advised treating such warty specimens with "a mildly cold dignity of demeanor."

A special kind of natural physiognomy, phrenol-

FIG. 8. Theriologic physiognomy. Early caricature illustrating the leonine type of man. (Della Porta, *De Humana Physiognomonia* [1601].)

ogy, was founded, as mentioned above, by Gall, a Viennese medical philosopher, who gave his first lecture on the subject in 1796. He based his doctrine on the premise that every mental faculty is represented by a special cranial proturberance. Each bump, he declared, is an index of the development of the cerebral region underneath, where the seat of that particular faculty is located (Fig. 10). Most important of all was his belief that each part of the nervous system has special functions.

In order to discover which parts of the brain are linked with a special function, Gall examined the heads of persons who showed strong manifestations of certain qualities, and contrasted them with other persons in whom the quality was weak. For example, he contrasted the head of a mathematical wizard of the day with the head of one of his own followers who had difficulty with the simplest of arithmetical calculations. Once having determined the significance of each area of the skull, he expected to be able to analyze anyone simply by examining cranial bulges.

Gall's method of investigation was crudely empirical, though, as we have mentioned, he resorted in some instances to the single-case method. Although he may have made certain erroneous assumptions, he was scientific in spirit, and it is unfortunate that disciples dragged his theory down to the level of charlatanry and into the realm of circus side shows. Some, too, were unable to resist the appeal of the stars and brought them into their schemes (Fig. 11).

What are the claims of somatomancy? This is a pertinent question, because in answering it we see many things which relate to the interests of modern human constitution, even though, of course, somatomancy lies almost wholly in the sphere of the divinatory arts. The hidden knowledge that physiognomists seek to reveal may lie in the future, the present, or the past. It may concern itself with happenings, with character, or with a condition of the mind or body. For example, one type of information which body divination claims to be able to supply is the criminal propensity of men. The phrenologist says that the potential murderer has a certain development of the organ of destructiveness, located under the temporal lobe just above the ear. The palmist says that the thief has, among other things, an exaggerated development of the Mount of Mercury. Efforts such as these adumbrate the more specifically formulated ideas of the nineteenth-century criminal anthropologists, among whom were Lombroso, Ferri, Garofalo, and Benedikt. Sometimes body divination goes beyond the determination of criminal propensities and enters the field of "discovery divination," which is used to detect and apprehend criminals or to decide guilt.

In medicine the part played by body divination has not been inconsequential. During the first half of the fifteenth century, when much medicine was astrological in character, the great physicians of the time who supported this approach had an influence on a whole host of lesser physicians, who, instead of consulting the stars directly, looked for celestial clues in the bodies of their patients. A perusal of the illustrious names in astral physiognomy during the Renaissance shows that the majority were in fact practicing physicians and that body divination was an accoutrement of their art. Nonastrological somatomancy has been even more influential than the celestial sort in medical practice, claiming greater antiquity and application, as well as more respectability.

One other application of body divination may be mentioned. In the business world, hardheaded

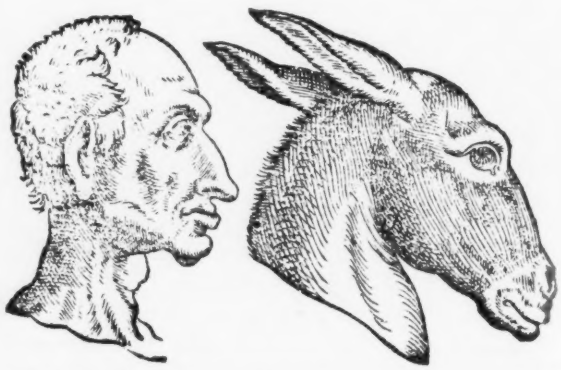

FIG. 9. Theriologic physiognomy. Early caricature illustrating the asinine type of man. (Della Porta, *De Humana Physiognomonia* [1601].)

employers have utilized principles of somatomancy in the selection of personnel. During the early part of the twentieth century an especially popular book by Blackford and Newcomb, called *The Job, The Man, The Boss,* gave advice for the hiring of men. This book set up certain "physical variables," as they were called, and described the variations in character which were supposed to accompany each. Even the Greeks were guided by physiognomy in filling positions.

For a wider understanding of somatomancy, we must turn to its sociocultural base. As a part of the universal phenomena of supernaturalism, it is man's response to the fulfillment of a need—the need to gain security in a world rendered fearful and worrisome by uncertainty, chance, and inadequate understanding of a wide variety of natural phenomena. Body divination, then, exists for the same reasons that magic and religion do.

The Renaissance and its beginnings provide a case study to support this statement. The great flowering of divination in general accompanied the revival of learning which took place during this period, when the foundations of modern life were taking on their unique features. In the general ferment leading to a period different in many ways from the preceding Middle Ages, Roger Bacon and Albertus Magnus, among others, were accused of crimes having to do with divination. The significance of the coming of the Renaissance is implicit in Cassirer,[1] who has said that if proof of the historical reality of the period were needed, it would be enough to point to two major works—Galileo's *Dialogues Concerning Two New Sciences* and Machiavelli's *Prince*. These strangely diverse books had one element in common. They were original and novel, and since they could not have been conceived by medieval minds, were sharp indicators of the sociocultural changes sweeping over Western Europe.

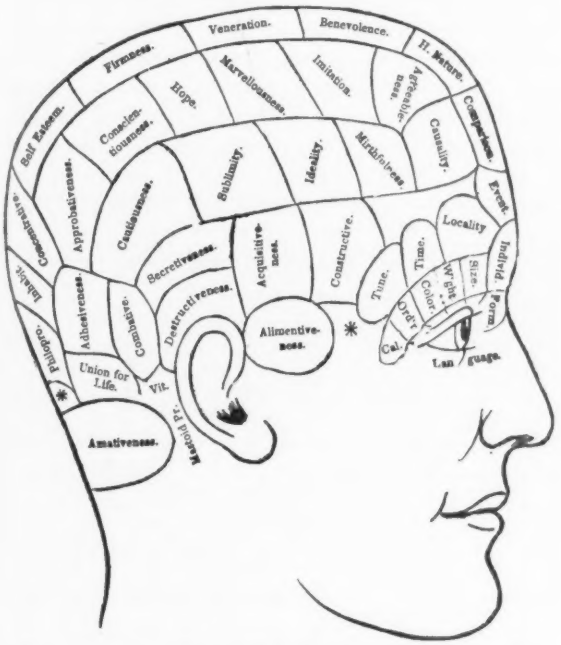

FIG. 10. Phrenology. The location of the faculties. (Fowler, *Practical Phrenology* [1851].)

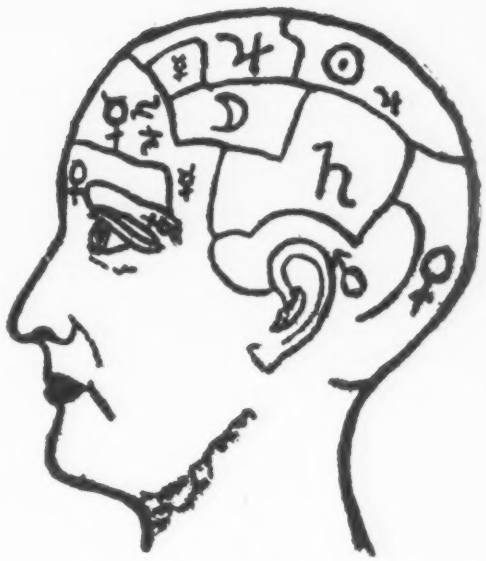

FIG. 11. Phrenological astrophysiognomy. The relation of the head to the planets. (Saint-Germain, *The Study of Palmistry* [1900].)

The Middle Ages had provided intense confidence in the *status quo,* in the neat, consistent, and dogmatic view of the world which medieval thought had adapted from Aristotelian philosophy. Security was provided for the individual by feudal collectivism, by the permanent station in society which the feudal system sanctioned, and by a clear and preordained meaning of life. In this world the individual had not been free, but he had been secure, and he was relatively incapable of seeing himself as a separate entity.

Contrasted with this, the Renaissance saw the accomplishment of great changes. The heliocentric theory inspired by Galileo and Copernicus not only shattered the terracentric view of the universe, but also severely weakened scholastic dogma and theology. Medieval collectivism foundered in the capitalism and competition sanctioned by the rise of individualism and personal initiative. The feudal system and the ideal of a great Christian commonwealth became attenuated in the rise of nationalism and the modern state. Hence, with these

changes, status became no longer so rigidly a matter of birth but was instead increasingly subject to individual action and the insecurities engendered by chance and uncertainty. Man could no longer search for an understanding of himself and his goals by referring to the traditional religious concepts. The new ruling force in the world of the Renaissance came to be not Divine Providence, but Fortune.

The dominant theme of the Renaissance, as far as we are concerned, is that man had "returned to himself." Man was forced to look to himself for the answers to questions which tradition and religious concepts no longer explained adequately, for although he ceased to be concerned with whence he had come, he became immensely concerned with whither he was going. Understanding of present position became essential, and in trying to establish a course of behavior, the element of chance intervened. The role of divination came to be that of attempting to control chance.

One more force related to the above factors impelled the individual of the Renaissance to turn to divination. Torn loose from the moorings of the Middle Ages, he had achieved a new, but insecure and anxiety-loaded freedom; being one's own master proved to be thoroughly discomforting. The feeling of anxiety and insecurity which freedom is capable of inflicting has been discussed by Fromm.[2]

We have examined a plausible theory to explain divination as resulting from man's need for comfort and reassurance, and to account for the greatly increased interest in divination which came about in Renaissance times. But we have not explained how the human body came to be used for divinatory purposes in the civilized world. The answer is not clear, but good guesses may be made. Physiognomy had been employed in the ancient civilized centers, probably as the result of an incipient spirit of "scientific" inquiry not incompatible with urban sophistication; but this form of divination had never attained first rank, as had nonsomatic varieties. Perhaps individualism as such did not really emerge until the Renaissance. At any rate, it seems reasonable for us to associate the use of the body for divinatory purposes with the new interest in man in himself as an individual; for somatomancy was in tune with the spirit of the times—with the search of man to understand himself. If clues to his own nature were to be found, what was more obvious than for the individual to look within himself for those clues, rather than in sand patterns, animal scapulae, pendulums, or natural phenomena—especially when new learning in medical and anatomical science fortified the particular orientation, and the two interstimulated each other?

Somatomancy merits the attention of historians, scientists, and theorists, because it is clearly one of the forerunners of the modern field of human constitution, which studies the total biological make-up of the individual in terms of varieties or types. It shares with it certain common assumptions, methods, and motivations. The first and most obvious circumstance which attracts our notice is that for each of them the human body is the starting point. Each makes classifications according to morphological traits, sometimes stressing over-all appearance and at other times selecting special features. The books of the physiognomist Della Porta are studded with pictures illustrating types of breasts, nates, trunks, knees, legs, feet, and facial profiles (Fig. 12). So are the writings of Taisnier, Lavater, Combe, and Delestre, to name but a few. Similarly, a perusal of books by constitutionalists is apt to reveal the use of drawings and photographs to illustrate classifications of various types of noses, palates, fingers, calves, hips, hair patterns, and the like. In describing various physiques as they see them, body-diviners use such terms as "jupiterian," "solar," "leonine," "bovine," and "lymphatic," whereas constitutionalists employ such expressions as "microsplanchnic," "pyknic," "muscular," "cerebral," and "ectomorphic" (Fig. 13). Classifications may vary considerably from one writer to another but are always indispensable, even where modern investigators ardently insist that they are not dealing with "types."

Regardless of the soundness of the typologies used and the methods employed for achieving them, the fact of the matter is that neither somatomanticists nor constitutionalists set up their classi-

FIG. 12. An early attempt at classification. Three types of facial profiles. (Della Porta, *Della Fisonomia dell' Huomo* [1615].)

fications as mere exercises. Rather, they feel that through an inspection of the body they can achieve more ultimate objectives. We find, accordingly, that each is interested in matters of disease, temperament, crime, and the like. Lombroso's writings on criminal types were to some extent inspired by the phrenological climate of the times and illustrate the gradual transition which in many cases has been made from somatomancy to constitution.

These grander objectives depend for their logical justification on a principle that is all-important. In modern jargon we might call it "functional consistency." Constitutionalists have insisted over and over again that the human organism is an integral entity, and without this premise they cannot proceed. They say that the biotype may be studied from various aspects, and that regardless of the approach used the ultimate results will be the same. If this sounds familiar and like what such ethnologists as Malinowski, Benedict, and others have said in the field of culture study, it is because of a similarity in outlook. Yet it forms part of the corpus of somatomantic belief, too. Three hundred years ago in his treatise on moles Saunders wrote, "And so, when as in the body all parts and qualities are so fitly dispensed and composed that they consist together in a unified fit natural proportion, so likewise is it in the soul, all things being so moderated and fitly composed that all the affections, as it were, in apt and set numbers and figures, conspire an harmonious accord."

The reason that physique is the most commonly used approach is obvious—it is the aspect most readily observed and classified, although it is vastly less amenable to classification than has generally been realized. Some authors are willing to go much further, seeing physique as a causal factor in the determination of other components of the biotype. Thus Seltzer declares,

> Not only does it [physique] provide the basic framework through which the individual functions, but its importance is more far-reaching in that the individual's physique is, in the main, biologically inherited, genetically determined. Body build being thus "a product of influences emanating from the germ plasm," is therefore a constitutional determinant in personality formation.[3]

To illustrate one of the common meeting grounds of body divination and biotypology, we may examine their attitudes toward "ugliness." Each sees it as indicative of undesirable inner traits. Long ago the Greeks coined a word, *kalosagathos* ("beautiful" + "good"), which expressed their conviction that beauty and goodness go hand in hand. A reverse application of this is found in the medieval dictum that if two men were brought

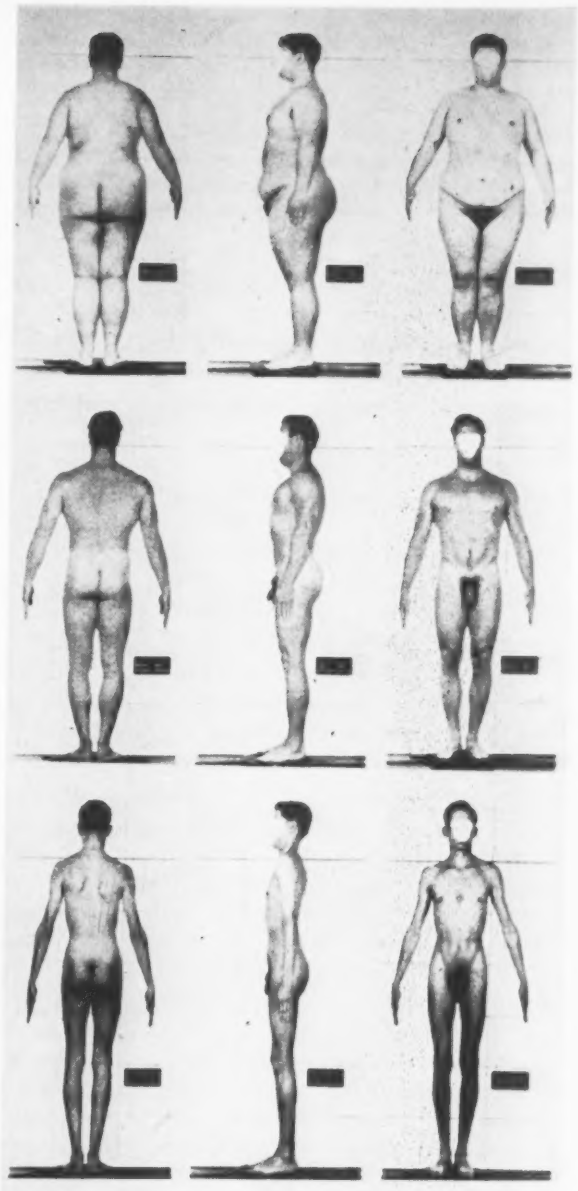

FIG. 13. A modern attempt at classification. Three extreme Sheldonian somatotypes: endomorphic, mesomorphic, and ectomorphic. (From an original of Pl. 1, C. W. Dupertuis, *Am. J. Phys. Anthrop.*, n. s., 8, 385 [1950].)

to trial for a crime and there should be indecision as to who was guilty, then the uglier of the two was to be hanged. Similar ideas, expressed variously in terms of dysplasia, disharmony, body disproportions, and bad modeling, appear in the constitutional literature. Mention has already been made of Quetelet's doctrine of the medial man. Further along these lines is a statement by Draper, the great American pioneer in constitution:

> In this connection one is reminded of the ancient Ger-

man medical adage *"Hässlichkeit stellt eine schlechte Prognose vor."* Indeed if one notes the general appearance of hospital ward inmates the average standard of beauty in the ordinarily accepted sense is surprisingly low. It is as though ugliness, being an expression of bad modelling in respect of features and body proportions, expressed in the morphological panel a sort of genetic bungling. In such folk, inadequacies in other phases of the total personality may not unreasonably be expected.[4]

Body disproportions have been the subject of a special study by Seltzer, who maintains that when they are present they indicate predisposition to a sensitive and complex personality, and when relatively absent are associated with vitality, directness, relative insensibility to fine influences, and good integration.[5]

Under the somatomantic and constitutional approaches, the individual rather than the group is the focus of attention. Insofar as constitution is part of physical anthropology, such an emphasis is notable for its novelty, for physical anthropologists are traditionally concerned with "human populations, their physical evolution, gene distributions, anatomical peculiarities, and patterns of physical growth, maturation, and aging."[6] This shift in emphasis corresponds to a similar shift in cultural anthropology, with its recent excursions into ethnopsychology. Interest in the group as such is not altogether absent, however, and in somatomantic writings of the sixteenth century and earlier we find attempts at racial, sexual, age, and familial patterns of morphology.

An unfortunate but all too real similarity between somatomancy and constitution is that both are almost authoritarian in their emphasis on biological factors. In medieval and Renaissance times an attempt was made to arbitrate the problem of human immutability versus human plasticity by invoking the concept of "free will" as a counterproposal to predeterminism, but foredestiny has nevertheless always remained implicit in most body divination. In analogous fashion, among constitutionalists there has long been a healthy division of opinion as to whether constitution partakes of environmental-cultural modification. Under the forceful leadership of W. H. Sheldon, the hereditary point of view has had new popularity by conceiving of the somatotype as immutable from birth. However, because of the barrage of censure leveled at him by critics (mostly outside the field), Sheldon has recently made a concession and coined the term "morphophenotype" to indicate the visible body structure, and "morphogenotype" to express the fixed genetic influence which persists in the organism, reserving the old term "somatotype" for the tentative representation of the morphogenotype. He declares that the morphophenotype changes with growth, aging, nutritional variations, and pathology, but that the somatotype delves beneath this and attempts to approximate the morphogenotype.[7]

It is abundantly evident that both somatomancy and human constitution have pragmatic goals, for both wish to enable individuals to benefit by the information which their findings disclose. They want to "accentuate the positive and eliminate the negative" by having people make the best of their favorable traits and carefully avoid the consequences inherent in their malignant ones. They believe in situational adjustments. Viewed from this angle, physiognomists, palmists, metoposcopists, phrenologists, and the rest of their kind are essentially advisers. On the other hand, biotypologists have not yet reached the practitioner stage because their discipline is still undergoing exploration, but it is nevertheless the avowed intention of these men ultimately to cast their lot with applied science. Indeed, some have already conducted considerable experimental research for the armed forces of the United States in the determination of various aptitudes. In Boston, Sheldon had begun therapy with the juvenile delinquents he was studying at the Hayden Goodwill Inn, when he was forced to stop because of the war.

If space permitted it would be profitable to explore the possibility that both somatomancy and constitution are, in part, responses to man's need to establish security. We have already examined the role of the mantic arts in this respect. Much of the appeal of the science of biotypology rests similarly on the hope that it can interpret for the individual his characteristics, capacities, and weaknesses. It forecasts, to some extent, and it also interprets some of the present and the past. There can be no doubt that if constitutionalists accepted clients in the same way that somatomanticists do, even though their findings are still highly tentative, they would have a tremendous practice.

It would be grossly unfair to stop at this point and leave the reader with an exaggerated notion as to the likeness between what is essentially an art resting on supernaturalism and a discipline based on experimental research. As we noted in our earlier discussions, somatomancy is often intuitive and eschews the experimental method. No serious account is taken of obvious discrepancies, except to explain them away with implausible excuses—the intervention of chance, errors in computation, and so on. When Cardano made the mistake of predicting a long life for Edward VI of England, who promptly died the next year at the age of sixteen,

he re-examined his calculations and discarded the method of Ptolemy, which he declared he should not have used.

In contrast to all this, the science of human constitution is overwhelmingly experimental. Hundreds and sometimes thousands of subjects are studied in order to discover even the simplest of correlations. Discrepancies are found, but ordinarily they are not glossed over; instead, they call for further research, further methods and techniques, and further revision of theory. Although interrelationships sometimes are observed without being understood, no recourse is had to mysticism to resolve the dilemma.

Unhappily, however, subjectivity is not altogether wanting in constitutional studies. One of the more obvious examples, afforded by the work of Sheldon, may be cited. When his *Varieties of Human Physique* appeared in 1940, his method of somatotyping (i.e., assessing physique) was described by some critics as involving a personal equation. Even Hunt, who uses the technique, concedes that "the attempt to rate the morphogenotype of an individual is highly subjective, has few operational referents, and is impossible to validate."[8] Howells has recently termed it "too much of an art and too little of a science."[9] Of Sheldon's *Varieties of Juvenile Delinquency* a famous criminologist wrote that "his definition of delinquency effectively removes this study from the area of empirical research and fixes it firmly in the area of homiletics," and "his method of scoring delinquency is subjective and unreliable."[10] W. C. Reckless says some of his themes are "fanciful" and certain methods of rating "dubious."[11] Washburn, noting with dismay that Sheldon has said phrenology is on the right track, concludes that his system has its roots in characterology, not science, and is "the new Phrenology in which the bumps of the buttocks take the place of the bumps of the skull."[12] Many critics impugn not only Sheldon's intellectual integrity but also his motives. They see in his eugenical crusade a new and virulent form of racism. Because his writings contain a mission, they have led Sutherland to say that his constitutional psychology is offered to us as "the Messiah for a world rushing into societal chaos,"[13] and Garn[14] to add, "the author assumes the mantle, and preaches more like Jeremiah than Hosea." Similar, though milder, accusations of subjectivity have been applied to other constitutionalists, such as Hooton and Kretschmer.

To sum up, it is clear that somatomancy and constitution, despite differences, manifest many analogies as well as downright resemblances. As has been shown, the origins of both not only spring from similar needs, but also are frequently embodied in the writings of the same investigators. Furthermore, the roots of science often are to be found among precursory magical and divinatory arts, and again are contained in the works of Renaissance giants or the culture of ancient endeavor.

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The Negro in Track Athletics

GEORGE P. MEADE

Mr. Meade, who is manager of the Colonial Sugars Company refinery in Gramercy, Louisiana, has written four previous articles for THE SCIENTIFIC MONTHLY. *The first, in June 1916, was an analytical study of athletic records. The others were "Youthful Achievements of Great Scientists" (***21,** *522 [1925]); "A Negro Scientist of Slavery Days" (***62,** *317 [1946]); and "The Natural History of the Mud Snake" (***63,** *21 [1946]). In view of this catholicity of interests, perhaps it should be emphasized that Mr. Meade's primary concern is with cane sugar technology and that his publications on sugar include some thirty journal articles, one book, and several chapters in books on related subjects.*

THE prominence of Negroes in track and field athletics has been a remarkable development in the United States in the past twenty-five years. The phenomenon has had little special publicity, and the extent to which Negro athletes have excelled is probably realized only by close followers of sports. Recently it has become more difficult to follow the trend because news agencies—the Associated Press and the United Press—as well as the sports writers for the large newspapers, have made it a rule not to mention whether an athlete is colored or white.

Two of the past three Olympic Games have highlighted Negro track and field performances: those in 1936 at Berlin, when Hitler's racist theories and his sneers at our "black auxiliaries" were much in evidence, and the recent games at Helsinki, where Negro participation was at sharp variance with Communist ideas about the status of our colored citizens. But in spite of these spotlighted occasions, exact statistics on the predominance of Negro athletes in certain Olympic events are hard to find, and similar detailed statistics for our national championships seem to be nonexistent. An analysis would appear to have scientific as well as sports interest.

Considering first the Olympics, we find that, in the games at Los Angeles (1932), Berlin (1936), London (1948), and Helsinki (1952), the United States won a total of thirteen "flat" races (i.e., races without hurdles)—the 100-meter and 200-meter in all four games, the 400-meter in 1932 and 1936, and the 800-meter in 1936, 1948, and 1952. Of these thirteen races, ten were won by American Negroes and only three by American representatives of the white race. In addition, Negroes took second in five of these races and third in five. If American-trained Negroes (not born in the USA) are included in this list, they add another first place, three second places, and three third places to the list. Of the 48 medals in these sixteen Olympic races 20 were distributed to American Negroes: Tolan (2); Metcalfe (3); Owens (2); Robinson, Williams, LuValle, Woodruff, and Dillard (1); Ewell (2); Whitfield (3); Stanfield, Gathers, and Matson (1); 8 to American-trained foreign-born Negroes: Edwards of Canada (2), La Beach of Panama (2), McKenley of Jamaica (3), and Rhoden of Jamaica (1), and only 6 to American white men.

To further complicate the picture, two English-trained Negroes (Bailey of Trinidad and Wint of Jamaica, won one first place, two seconds, and a third, so that of the medals awarded in these four highly competitive "blue-ribbon" events, to which American Olympic triumphs (so far as flat races are concerned) have been limited since 1908, 32 have gone to members of the Negro race, and only 16 to all white competitors of the world, including those of the United States.

One other Olympic event has been dominated by Negroes—the running broad jump. American Negroes won this event in 1924 (Hubbard), 1932 (Gordon), 1936 (Owens), 1948 (Steele), and 1952 (Biffle). In 1952 a Negro took second place (Gourdine), and in 1948 Negroes took third and fourth places (Douglas and Wright). A Haitian Negro, Cator, was second in 1928 in the only broad jump in the past six Olympic games in which a white man won first place. The distribution of the medals in this event since 1924 shows eight to American Negroes, one to a Haitian Negro, three to American white men, and six to all other nations combined.

In the six American Olympic relay teams since 1936 half the competitors have been Negroes, and

in the 1600-meter relay event at Helsinki, the Jamaican all-Negro team broke all world and Olympic records in 3 minutes 3.8 seconds, or an average of under 46 seconds for 400 meters.

Two other Olympic events have been won by American Negroes—the high jump in 1936 by Cornelius Johnson, with David Albritton, another Negro, second, and the 110-meter hurdles in 1952, where Harrison Dillard, whose triumph in 1948 in the 100 meters had been unexpected, came back to win and set an Olympic record in his specialty, the high hurdles. Second place in the decathlon at Helsinki went to Milton Campbell, a Negro high school student from New Jersey. All these Olympic performances are notable not only for quantity but for quality. Most of the winners named established Olympic records, five of which still stand. A further noteworthy point is that the Negro members comprise only about 10 per cent of our Olympic track and field squads, so that their share of medals is far out of proportion to their numbers; in fact, the Negro who competes in the Olympics and does not score is a rarity.

Turning now to our national competition, the excellence of Negro competitors was first demonstrated in the broad jump, beginning in 1920 when Sol Butler of Dubuque won the National Amateur Athletic Union championship. During the succeeding thirty-two years through 1952 the national broad jump championship has been won twenty-five times by representatives of that race. Ned Gourdin of Harvard, the first man in the world to jump 25 feet, won in 1921, then DeHart Hubbard of Michigan won for the following six years and successively raised the world record to 25 feet 10 inches. Hubbard won the Olympic championship in Paris in 1924, the first of the Negro Olympic winners. Only five white broad jumpers have been able to capture the gold medal in the national AAU championships in the past thirty-three years, but in the same period fourteen different Negroes have won this event. In this group are five Olympic champions—Hubbard, Gordon, Owens, Steele, and Biffle. Also included in the list is Eulace Peacock, whose jump of 26 feet 3 inches in 1935 is still an AAU championship record. The first man to clear 26 feet was Silvio Cator, the Haitian Negro who placed in the 1928 Olympics, after which Chuhei Nambu of Japan jumped 26 feet 2 inches for what was then a world record. Jesse Owens, trained at Ohio State University, improved this mark suc-

Finish of the Olympic 100-meter dash at London in 1948, won by Harrison Dillard, extreme left; second, Barney Ewell, No. 70 (both USA); third, Lloyd La Beach, American college-trained athlete running for Panama. The Negro running in the second lane (No. 35) is E. MacDonald Bailey of Great Britain who finished sixth. Four of the six finalists are Negroes, representing three different countries.

cessively until the present 26 feet 8¼ inches was reached. Owens is unique in modern sports in that he has held four world records simultaneously in three diverse events—the sprints, the low hurdles, and the broad jump. By many he is considered the greatest track athlete of all time. Peacock, Steele, and more recently George Brown, have bettered 26 feet, but no member of the white race has ever reached that mark. The indoor AAU broad jump championships have shown an even more impressive listing because not only have most of the winners been Negroes, but in many of these contests the finalists have practically all been Negroes.

Negro accomplishments in the sprint races are as impressive as in the broad jump, although the dominance is not of as long-continued standing. The earliest of all the great Negro track athletes was Howard Drew, who equaled the world records in the 100- and 220-yard dashes as far back as 1912. Most of the broad jumpers of the twenties were topnotch sprinters, but it was not until the rivalry of Tolan and Metcalfe in the early thirties that Negro sprint champions became the rule rather than the exception. In the twenty-three years since Tolan first won the national AAU outdoor championship at 100 yards, this event (or its counterpart, the 100 meters) has been won seventeen times by a group made up (with Tolan and Metcalfe) of Peacock, Owens, Ben Johnson, Ewell, Young, Mathis, Stanfield, Bragg, and Golliday. In many of these highly competitive national championship events Negroes have taken first, second, and third, and one year all six finalists were Negroes.

The picture in the longer dash (either 220 yards or 200 meters) is practically the same. Tolan and Metcalfe dominated this event in the early thirties and were followed by Mack Robinson, Ewell, Elmore Harris, La Beach, Stanfield, and Tyler. As in the shorter sprint, in many of the national championships all three medals for the 220 have gone to Negroes. A startling statistic in the AAU indoor sprint championship (60 yards or 60 meters) is that for sixteen successive years Negroes won the event. Metcalfe, Ben Johnson, Herbert Thompson, Mozel Ellerbe, Ed Conwell, Ewell, and Tom Carey are the names that make up this uninterrupted succession of triumphs.

The middle distances show fewer representatives, but many of these have been great. In the quarter-mile (or 400 meters) the Jamaican Herb McKenley, trained at the University of Illinois, held the world record at 45.9 seconds, and George Rhoden, another Jamaican, who is a student at Morgan State College, Baltimore, Maryland, is the present holder at 45.8 seconds. Both Rhoden and McKenley have been mentioned as Olympic point winners, and Rhoden is the present Olympic champion and record holder at 400 meters. Elmore Harris is credited with the fastest quarter-mile ever run on a "closed track" (i.e., starting and finishing at the same point) at 46.3. Not since 1943 has a white man won the national championship in this event. Archie Williams and Jimmie LuValle have been mentioned as Olympic medalists in 1936; and Wint, the Jamaican, set the Olympic 400-meter record at London in 1948, which Rhoden broke at Helsinki. Williams held the world record for the quarter-mile for several years at 46.1 seconds.

Canadian-born Phil Edwards, trained at New York University, won indoor and outdoor championships at 600 yards and the half-mile and was third in both the Olympic "half" and "mile" (800 meters and 1500 meters) at Los Angeles in 1932. He took third in the Olympic 800 meters and fifth in the 1500 meters at Berlin in 1936, possibly the only man to place in both these events in two successive modern Olympic games. James Herbert and Dave Bolen are Negro stars that have won several 600-yard indoor national championships, and Bolen placed fourth in the 400 meters at the London Olympics. Reginald Pearman, a member of the 1952 Olympic squad, was national half-mile champion in 1947 and winner of several indoor national championships. Whitfield and Woodruff have already been mentioned as Olympic 800-meter champions. Whitfield is the present Olympic record holder, and Woodruff is credited with the fastest half-mile ever run in America. Frank Dixon, New York University, was indoor mile champion in 1943 with a mark of 4:09.6, the only Negro in the select group of milers who have bettered 4:10.

Possibly the greatest Negro middle-distance runner was the late John Borican, who died in his prime. His are still the indoor world records for 600 and 1000 yards, and three quarters of a mile, and he was national 1000-yard champion from 1939 to 1941. Borican was pentathlon champion for three years and in 1941 was the first man in AAU history to win both the pentathlon and decathlon. These events require great versatility as well as stamina. Other Negro pentathlon champions were Edward Gourdin of Harvard in 1921 and 1922 and Eulace Peacock, who won in 1933 and 1934 and again in 1937, and then came back to win in 1943, 1944, and 1945. In the decathlon, Bill Watson of Michigan was champion in 1940.

The high jump offers an interesting study. The

George Rhoden winning the 400-meter national AAU championship in 1951 in 46.0 seconds. Herbert McKenley, second. Rhoden is world and Olympic record holder at 400 meters and McKenley was the former record holder. Both are Jamaican-born but American college-trained.

first Negro champion was Cornelius Johnson, who won the national championship in 1932, while still a schoolboy. He was the Olympic record holder until the Helsinki games and was co-holder in 1934 of the then world mark of 6 feet 8⅝ inches. Other great Negro high jumpers are David Albritton and Melvin Walker of Ohio State; Joshua Williamson of Xavier University and Adam Berry of Southern University, both of Louisiana; and Ed Burke of Marquette University—all of whom cleared 6 feet 8 inches or better. Between 1932 and 1948 this group won or tied in twelve national championships and in one of these years only one white man was among the six finalists. Edward Burke's indoor jump of 6 feet 9¼ inches is still a world indoor mark from a board take-off, and Walker's jump of 6 feet 10¼ inches was a world record at the time it was made. No recent addition to this group of great Negro high jumpers has appeared, and the champion high jumpers are now all white men.

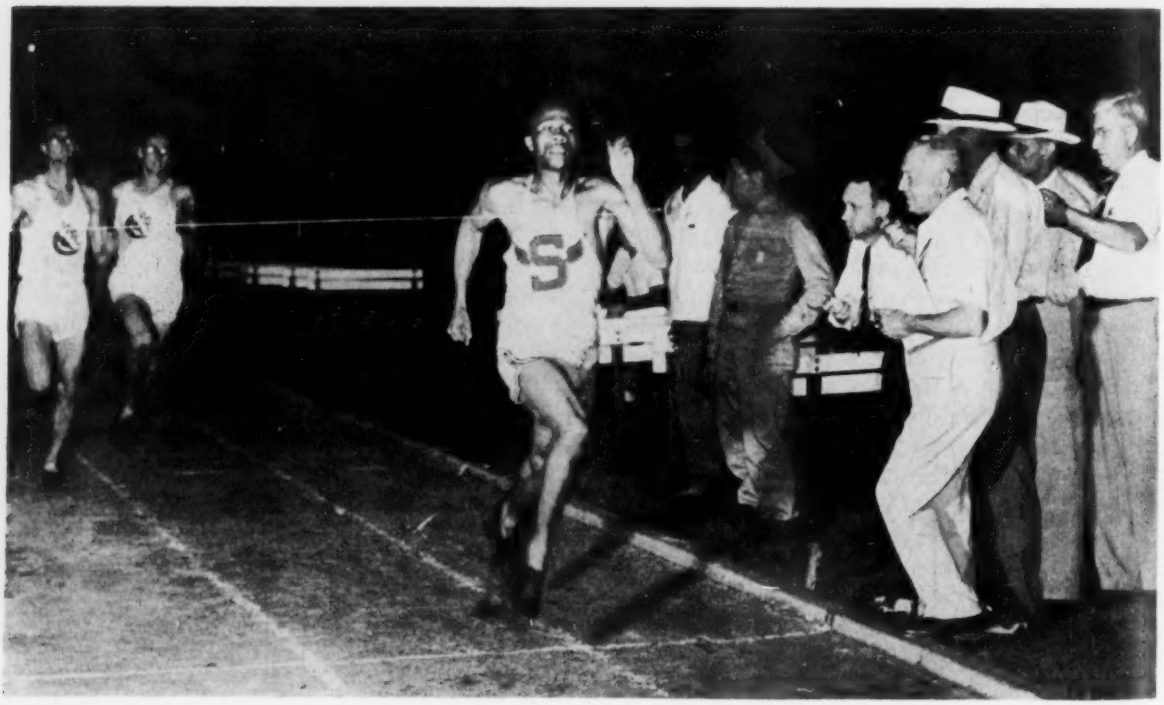
Three or four hurdle champions have been Negroes, the most brilliant being Harrison Dillard, world and Olympic record holder in the high hurdles and of the 220-yard low hurdle world mark at 22.3 seconds. Dillard distinguished himself at the Olympics in 1948 by winning the 100-meter flat race (equaling Tolan's record) after he failed to qualify in his specialty, but he won the hurdles at Helsinki in record time. Jesse Owens held the world mark in the "lows" for many years at 22.6 seconds. Charles R. Brookins, one of the earlier Negro stars, was national low hurdle champion in 1923 and in 1925, and for many years he held the world record for the event run around a turn. Ed Dugger of Tufts was national indoor hurdle champion for several years before Dillard took over.

From the foregoing it is evident that Negro champions have predominated in those events requiring speed and agility, but for some unexplained reason none has ever starred in the pole vault. The weight events generally have not attracted Negroes, but they have supplied at least two outstanding performers. In the shot-put Charles Fonville of

Michigan University was the first man in the world to achieve a distance of 58 feet, which stood as a world record until recently. Another great performer was Archie Harris, whose mark of 174 feet 8 inches with the discus was an American and world record for several years. These two weight events complete a list of world records held by Negroes covering all the flat races up to half a mile in both yard and metric distances, the high jump, the broad jump, the high and low hurdles, the shot-put, and the discus throw. Exactly half the "standard" events in AAU competition have had Negro world record holders at one time or another. When American records are also considered, the list includes at least thirty Negroes, and the number of records that have been held by them exceeds fifty.

In this summary only Olympic champions or point winners, national outdoor and indoor champions, and world or American record holders have been mentioned. These are the elite of track stars, and no attempt has been made to stretch the list by including college and district champions.

The question naturally arises as to why such a small segment of our population has provided such a large proportion of extremely high-class performers. Some anthropologists have indicated a racial difference in the comparative lengths of the leg bones and in the foot structure, but it is difficult to believe that anatomical differences are the principal reason. With such widely differing types among a group of champions as the short and stocky Tolan, the large and rangy Metcalfe, and the streamlined Owens, minor differences in bone structure would hardly seem to be the determining factor. Possibly the explanation is sociologic rather than ethnologic. Track meets were among the earliest athletic contests in which Negroes were free to compete with white athletes, and when a few champions developed this attracted others, and the trend of the twenties became the avalanche of the thirties. To support this hypothesis, it is a recognized fact that certain institutions and certain countries produce champions in specialized groups. Yale University for years had a long line of pole-vault champions, Cornell used to excel in distance running, and practically all the recent hammer-throwers and 56-pound weight men have come from a few New England colleges. No one would claim that the Finns are racially better fitted for throwing the javelin or that the Swedes are anatomically better mile runners, even though at least six Swedes have run the mile under 4:06. Example and "fashion" are great forces in these



Dave Bolen of Southern University winning the Junior 400-meter AAU championship at San Antonio, Texas, in 1946. The author, one of the official timers, is second from the right. Bolen was national 600-yard champion in 1948 and 1949 and took fourth place in the Olympic 400-meter at London in 1948.

matters, and it may be that the same factors have tended to produce so many Negro champions. Of special interest is the experience in the running high jump. Why did Negro stars dominate this event for about fifteen years and then cease to do so? This might bear out the contention of some students of sports that Negro prominence is a passing phase rather than a permanent one. Lending reinforcement to such a theory is the predominance of Irish-American athletes in the list of record holders forty years ago, whereas today they are not especially prominent.

One fact that stands out in this study is that Negro athletes stay in competition much longer than their white colleagues in the same events. Eulace Peacock, Edward Gordon, Dave Albritton, Barney Ewell, and many others have been in the forefront and have won championships for spans of twelve to fifteen years, most unusual in events such as sprints and jumping, which require intense training and accurate coordination. Most white athletes in these events drop competitive track work soon after leaving college, but the majority of the Negro champions not only compete but continue to win well into their thirties. This persistence may possibly be due to lack of other opportunities for self-expression.

From the facts presented here the evidence is clear that members of a sharply delineated group comprising about 8 per cent of our population have excelled, far beyond the proportion to be expected, in a highly competitive activity that has great popular importance. Track work is unique in the major sports in that it is not a preparation for a professional career, as are baseball, football, basketball, and boxing, and therefore no monetary attraction is involved. A further limitation is that track and field athletes are almost entirely developed in the colleges and universities. Those mentioned here are representatives of institutions throughout the country, and not of any particular section. Whatever the reason or reasons may be, the showing of Negro athletes in these specialized techniques is noteworthy, and the purpose of this compilation is to preserve the data in a form for future reference.

TELEPHONE

Over the miles of space,
The electric spirit wings;
And I wait in this quiet place
As the striving wire sings.

I seek you wherever you are
Over the thousand hills,
Under the single star
That I see past the sills.

Swifter than swallows in flight,
Swift as the flash of sun,
On the avenues of night,
The unseen course is run.

DANIEL SMYTHE

Schenectady, New York

SCIENCE ON THE MARCH

HUMAN ENGINEERING: THE STUDY OF THE HUMAN FACTOR IN MACHINE DESIGN

IN THE foreword to the Tufts College *Handbook of Human Engineering Data*,[1] Admiral Luis deFlorez says:

> The amazing progress of science and technology in our time, which has endowed mankind with virtually unlimited physical power, has brought with it a gigantic responsibility. Achievements such as the mobile power of the internal combustion engine, the conquest of geographical barriers by the airplane, the boundless communications made possible by electronics, and now atomic fission with all its ramifications have provided the means of performing miracles and producing catastrophes. . . . Up to the present, we have been able to keep up with technological progress by education and training. But we have now reached the point where the machine has dwarfed the man, for the characteristics of the individual—the human machine—have not changed in the memory of man and will not change for countless generations to come, while the man-made engine is capable of ever increasing power, scope, and speed of operation. We must, therefore, consider man's capabilities as a constant in contrast to the unending progression of the machine.

It is the purpose of this paper to summarize briefly some recent efforts that have been directed toward solving this dilemma. A few words of historical introduction may be appropriate.

Early in the Machine Age initial attempts to provide increased production consisted of greater employment and improvement of the machines themselves. The worker, or the operator of those machines, received little or no consideration. As early as 1829, however, it was observed that

> We have been very much occupied in perfecting the machines and tools which the worker uses in the economic arts. We have hardly attempted to improve the worker himself. However, if he were only considered as an instrument, a tool, a motor, he would necessarily be placed in the first rank of all instruments, all mechanical agents, since he has the immeasurable advantage of being an instrument who observes and corrects himself, a self-stopping motor which functions with the motivation of its own intelligence and which perfects itself by thinking not less than by work itself.[2]

Nevertheless, it was not until near the end of the nineteenth century that any real efforts were made to provide for coordination and integration of the capacities of men and machines. This movement was led by F. W. Taylor. Because of his efforts to simplify and standardize the motions made by workers in numerous industrial jobs, he is considered the founder of the fields of scientific management and motion study.[3] Subsequent to his contributions, a number of other investigators, particularly the Gilbreths, developed the field of time and motion study, which has led to the well-established areas of industrial engineering known as time and motion economy and efficiency engineering.

Thus the first group to attempt to utilize human engineering principles consisted of engineers making contributions to what would now be called psychological problems. The field of industrial engineering, however, has concerned itself mainly with applications to existing machines, devices, and procedures. In general, the attack has not involved modifications in original design.

Somewhat prior to the birth of management engineering, it was discovered that a significant body of knowledge and information about basic human capacities and limitations could be gained by empirical investigations of human behavior rather than by philosophical deliberation. Experimental psychology was established as a field of endeavor about 1879, when Wilhelm Wundt founded the first experimental laboratory at the University of Leipzig. Experimental psychology spread rapidly thereafter and led to the early work done in laboratories at Cornell, Harvard, Columbia, Clark, and Johns Hopkins.

The growth in this field has constituted the core of what many regarded as the field of academic psychology as taught in most of our educational institutions during the first decades of the twentieth century. Experimentation in the area has generated a rather large body of knowledge concerning the capacities of the average human adult and the psychological nature of such functions as sensation, perception, learning, intelligence, emotion, thinking, motor responses, reaction time, and so on.

Another trend in which we are interested has been the study of individual differences and the development of personnel psychology.[4] The first experimental investigations of individual differences were made by Sir Francis Galton and are exemplified by the tests, both psychological and anthropological, which he instituted at the International Health Exhibition in London in 1884. From this beginning the mental testing movement

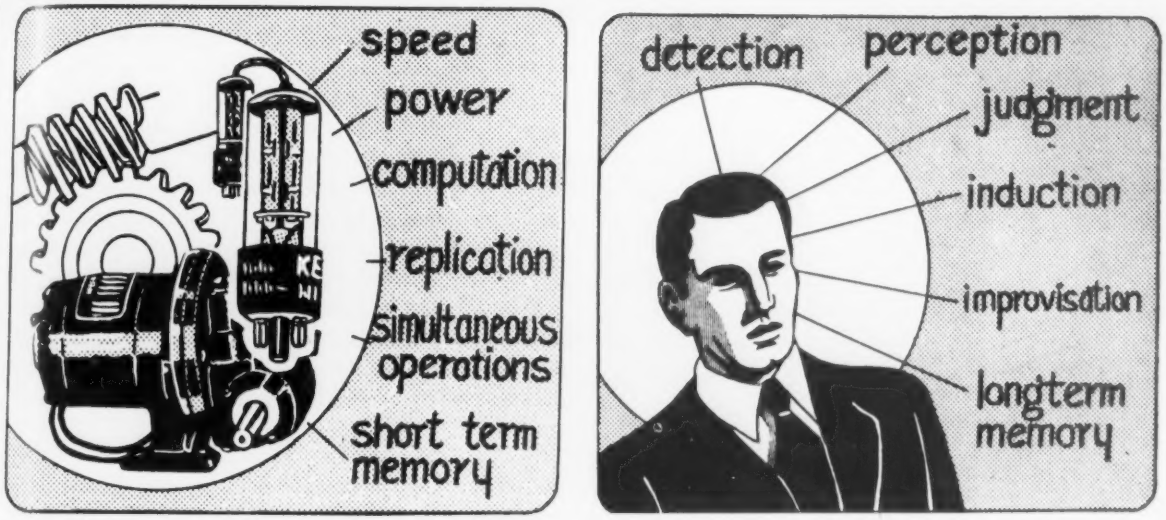


FIG. 1. Left, functions which machines generally perform better than men; right, functions that men generally perform better than machines. (Both after Fitts.)

developed. We are all familiar with the intelligence and aptitude tests the development of which was spurred by the events of World War I; these were exploited thereafter for use in World War II.

During World War II, however, it was found that, even with the application of the best selection and classification devices then known, the most up-to-date training techniques, and the most refined techniques of time and motion economy, there were many instances where military operators were unable to perform the tasks which complex modern warfare and its instruments demanded.[5] Time and time again it was found that the weapons, instruments, and equipment which engineers had produced, which were often ingenious applications from physics, electronics, and chemistry, were incapable of being operated proficiently by the average American GI. It became clear, for perhaps the first time, that the human being could be the factor that prevented an engineering device from performing to its full specifications, and striking experiences of this sort nurtured the notion that complex equipment must be designed with built-in human factor considerations.

The evolution of a field of human engineering was inevitable. It has as its prime goal the achievement of optimal man-machine relations. It asks the twofold question, How can the man be selected and trained to operate the machine most efficiently, and how can the machine be designed so that the man *can* operate it most efficiently? In one instance we select the man; in another, the machine.

Figure 1 illustrates the functions that machines can generally[6] perform better than men, and also the functions that men can (at least up to this moment!) generally perform better than machines. The differences seem embarrassingly obvious, but one point requires emphasis. Machines can be modified or redesigned. Men can only be selected and trained to use what they have with maximum efficiency—the limits are firmly fixed.

An approach to the area of human engineering may be introduced and summarized with the statement that we are studying man as, or as a part of, a servomechanism, where the servomechanism matches an output with a varying input or reproduces the input at a higher power level. Certainly, when the human operator is considered in this light, it is clear that there are biological, psychological, and engineering aspects to the problems that arise. Ultimately we are interested in predicting the final over-all performance of a system that includes a human element, but the prediction cannot be made before the operating characteristics of all the elements of the system have been determined.

Although the servo-analogy may be extended to men working alone, men working with machines, or machines working alone, we shall concern ourselves with the single man-machine pair. Figure 2 illustrates a human element in a simple servo-analogy. In such a situation one can hardly maintain that the over-all efficiency of the unit is more or less dependent upon the machine element or the human element. Certainly the machine element has been well engineered, and those who engineered it have determined its characteristics of lag, slip-

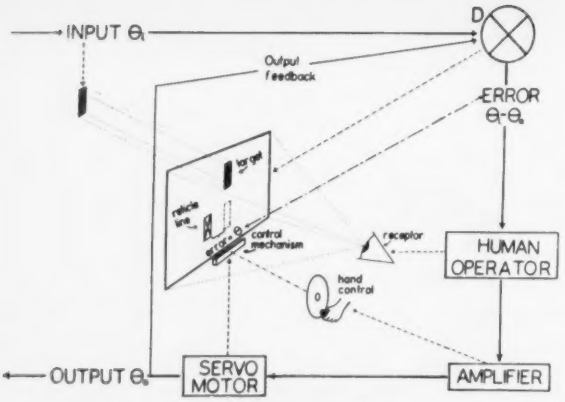


FIG. 2. The schematic servo-analogy above shows a human operator as, and as a part of, a servo-system.

page, stiction, friction, and torque as well as of linearity of response. Likewise, the human element has been rather nicely engineered, in spite of the fact that human engineers were not consulted in the planning stage. It becomes one of the first tasks of the human engineer to know or determine the characteristics of the human element that are important in a particular situation.

Returning to the servo-analogy in Figure 2 for a moment, we can say that the human engineer must know or determine the following in this situation:

1. The sensory capacity of the operator. How well can he discriminate changes in target-reticle relations?
2. Sensory-motor capacity of the operator. How rapidly, consistently, and accurately can he initiate a movement in response to a change in target-reticle relations?
3. Motor capacity of the operator. What kinds of movements can he make? How rapidly, accurately, and consistently can he make them? How much force can he apply?

In addition, either the engineer or the human engineer must know or determine the characteristics of the following:

1. The input provided the operator—in this case the relation between target and reticle.
2. The input demanded by the machine—how much torque, friction, or inertia must be dealt with?

Given the foregoing information, we can answer the questions: What does the operator have to respond to? Can he respond to it? How rapidly? How accurately? How consistently? What are the force and rate requirements of the machine? Can the operator meet them? Consequently, we can predict the over-all performance of the system. If we should find that predicted performance fails to meet specification, we can readily determine why and take steps to bring performance up to specification.

To proceed from the foregoing specific example to a generalized analysis of a single man-machine system, we find that the design problems encountered can be categorized as either *display* problems or *control* problems. By a display we simply refer to those aspects of a device that provide sensory input to the operator. The display may, of course, be visual, auditory, tactual, kinesthetic, or other, although we usually think of displays as involving the presentation of visual information. By a control we mean that aspect of a machine whereby the motor responses of the operator direct the machine in its proper function. We are referring to such familiar objects as wheels, knobs, levers, switches, pedals, etc.

Let us consider the general field of instrument displays. Any particular display may be either *pictorial* (realistic) or *symbolic*. The display in Figure 3 attempts to give the information in realistic and natural fashion without distortion of critical relation, whereas a symbolic display may bear no clear, simple relation to the way the information would be perceived through man's sense channels if it were received in the natural environment.[6] Figure 3 also shows a symbolic display giving the same information as the realistic display; the information here has been transformed into an abstract numerical and letter scale.

Although our illustrations may imply that only visual displays may be either pictorial or symbolic, the same dichotomy may be drawn for other types of display. In audition, sonar yields a symbolic display, whereas a direct listening system presents a realistic display. Speech forms, for the most part, a symbolic display; however, the onomatopoeia, although rare, may be considered a pictorial display. The dichotomy may be carried further to a comparison of the musical forms of Bach and Debussy.

In tactual displays the dichotomy also appears. Ordinarily knob controls in aircraft are uniform in shape—symbolic displays. Recently, though, control knobs shaped like the member they control have been tested; i.e., knobs for propeller or flaps have been shaped like propellers and flaps—pictorial displays. A recent study[7] has evaluated our capacity to discriminate between knobs having letter shapes by means of our sense of touch.

A pictorial, or realistic, display has the advantage of being easy to interpret because it is normal to our everyday perception; it is especially adapted to show relational information—the extent to which something is more, less, bigger, smaller, farther, nearer, etc. Examples are polar coordinate plots and television pictures. Unfortunately, how-

ever, a pictorial display is often very difficult to adapt to a particular machine situation, especially in the area of audition.

Symbolic displays are the kinds which are more commonly used and with which we are most familiar, even though they lack the advantage of having perceptual naturalness; examples are tachometers, clocks, pressure indicators, many kinds of charts, tables, etc. Symbolic displays are more accurate, and they are best suited for the presentation of discrete single-item types of information. Also, of course, being more conventional, more people are willing to use them.

If we classify the various functional uses of symbolic displays, we find that they fall into three main groups. The first and simplest function of a symbolic display is that of *check reading*. In this instance, all that the operator learns from the instrument is whether a particular situation exists. Examples are warning and indicator lights, sound alarms, or electrodes in your easy chair that may be used to show whether the cellar light is on or which one of the main dynamos has developed a malfunction.

A second major use of a symbolic display is the indication of *qualitative* information. In this instance we are interested in determining not only whether a particular condition exists, but whether the condition is changing in a desirable or an undesirable direction. Oil gauges or variable frequency sirens provide examples.

The third and most conventional use of a symbolic display is to show *quantitative* information in abstract numerical form. The clockface circular dial showing miles per hour, pounds per square inch, revolutions per minute, etc., is a common illustration of what we have in mind here, although many other kinds of information may be presented in dial shapes that are horizontal, vertical, semicircular, or of an open-window form.

Considerable human engineering research on quantitative visual indicators has been performed during the past few years. Without going into the details of the research, we shall simply list some of the questions of dial face design that have now been answered:[1, 8-10]

1. What should be the size of the dial and its elements? This question includes a consideration of viewing distance, numeral size, graduation mark size, pointer size, etc. Its answer requires information on visual acuity and resolution of the eye.
2. What should be the characteristics of the scale? Where is the origin—the null position—if any? Should the scale be linear, logarithmic, unit, or decimal? The information required here involves rather complex perceptual functions.
3. Under what conditions of illumination can the dial be used effectively? This question requires information regarding visual acuity, brightness discrimination, contrast sensitivity, and color vision.

Information of this kind is useful in many domestic, commercial, industrial, and military situations. Figure 4 illustrates the growth in aircraft instrument panels over a twenty-five-year period. Bringing the instrument panel up to date required the addition of some 20 or 30 indicators. To this complexity add the instrument reading requirements of high altitude, high speed, and, especially, night and all-weather flight and then require that a large amount of attention be given to intricate motor responses and to communication within and without the aircraft. It is not surprising that a

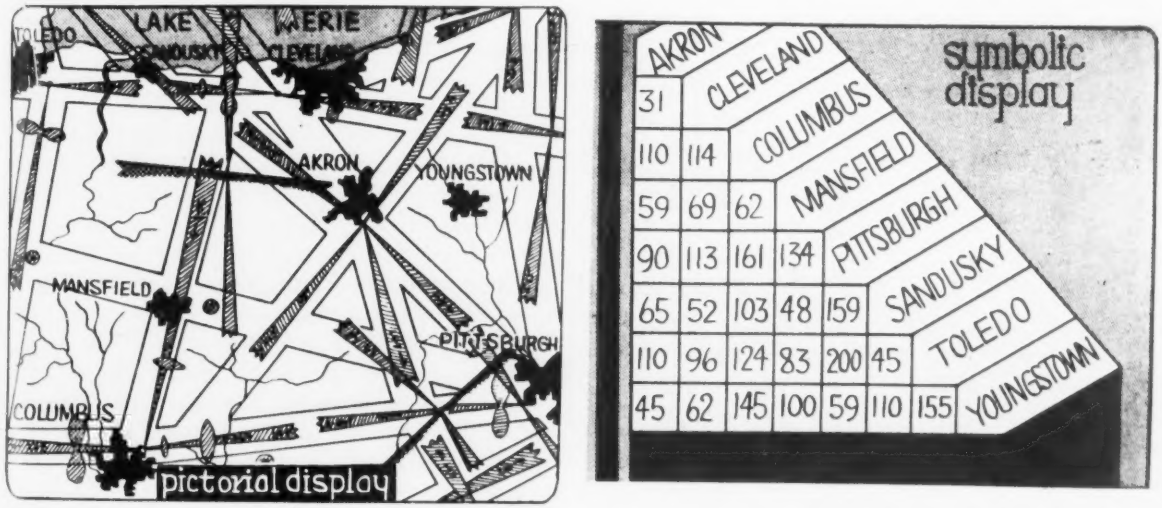


FIG. 3. Left, a pictorial display presenting its information in a realistic, natural fashion; right, a symbolic display presenting the same information. (Both after Fitts.)

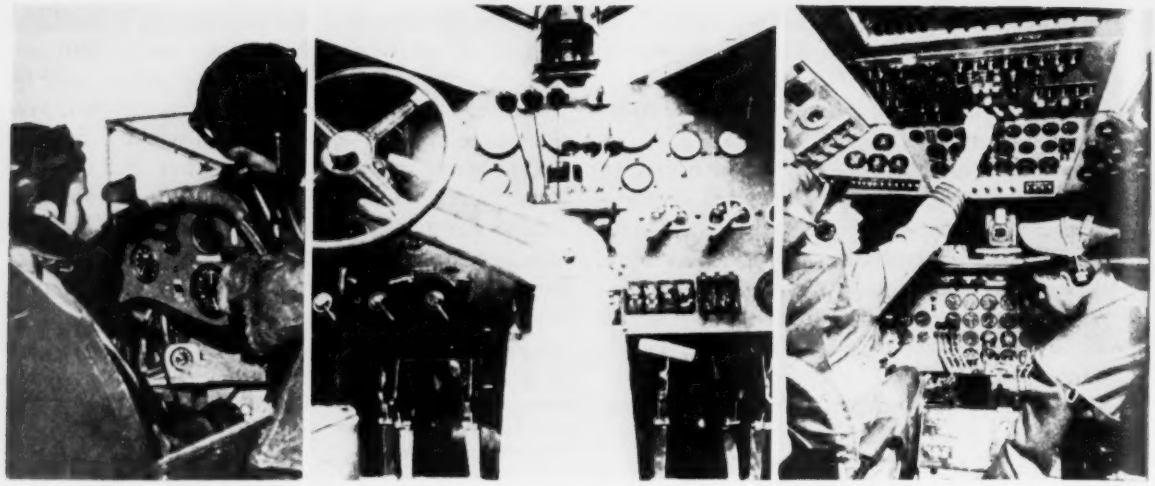


FIG. 4. Cockpit contrasts: Left, in the 1920s pilots had few instruments and relatively little to watch inside the cockpit; center, the 1930 cockpits were complicated mainly by the addition of multiple engine controls, but they were still within the capabilities of a single pilot's comprehension; right, the complicated cockpit of a modern air liner (in this case a Douglas DC-6) requires the combined and continuous attention of two or three men. Modern practice puts engine controls in the hands of a flight engineer. (Johnston, S. P. *Technol. Rev.*, **49**, 503 [1949]. Used by permission.)

recent survey conducted by psychologists at Wright-Patterson Air Force Base showed that a large proportion of military aircraft accidents or near accidents attributed to pilot error could be traced to errors in reading or interpreting instruments. An aircraft accident today often involves civilians on the ground, several men in the crew of the ship, thousands of hours and dollars spent in the training of the crew, and a million- or multimillion-dollar piece of equipment. If research on any of the questions posed above contributes to simplifying the pilot's job and reducing pilot error, that research would appear well justified.

As a single partial instance of the accomplishment of such research, consider for a moment the relative ease of reading of the old and new altimeter faces shown in Figure 5. Almost 75 per cent of altimeter reading errors are eliminated by the redesigned instrument.[11]

Beyond the separation of auditory displays into realistic and symbolic, it is possible to identify two classes of auditory information. Auditory signals may be either tones (signal alarms, code transmission, etc.) or noises (the symbolic sounds used in voice communication).

As an illustration of the manner in which the data of audition are employed in an engineering application, we may consider a system such as echo-ranging sonar. Neff and Thurlow[12] have summarized the kinds of auditory discriminations required of the sonar operator as:

1. Detection of a tonal signal masked by a background composed of an irregularly modulated tone and of noise, the signal differing from the background principally with regard to loudness or pitch. The rate of change of loudness—the abruptness of the echo—is also a factor to be considered.

2. Recognition of changes in the tonal signals masked by the tonal and noise background, the changes being those of pitch, loudness, duration, and quality.

The human capabilities and limitations for the perception of tones and noises are fairly well mapped out. Besides loudness and frequency thresholds, the ability of the ear to detect changes in pitch as a function of the frequency of the signal being perceived is known. The ability to detect changes in loudness as a function of the loudness level of the signal is known. More complex relations, such as the effect of varying signal-to-noise ratios on percentage of articulation or comprehensibility of speech sounds as a function of the loudness of the speech signal itself, have been determined. As a matter of fact, it is now believed by many that the development of communication equipment for the transmission of tones or the noises of speech is primarily a matter of engineering design and economic factors rather than a need for additional information concerning human auditory perception. There exists at present, however, a vigorous research and development effort by human engineers as a part of the contemporary emphasis on communication theory.[13, 14]

A third important quantitative symbolic display involves the presentation of tactual cues. Some data are now available for situations in which touch alone is used to obtain sensory information.

This would be true if one manipulated controls in the dark or if the eyes were otherwise occupied. Figure 6 shows a series of eleven knob shapes that have been shown by experiment[15] to be seldom confused with one another. In other words, in a situation in which one had to rely solely on the feel of the control, these shapes would offer the possibility of eleven different knob contours for an equal number of control channels, with the minimum possibility of confusion among them. Although research on tactual displays has been limited, certainly other possibilities exist for the presentation of information through the tactual modality.[7, 16]

Although most, if not all, research on displays has been directed toward the development of visual, auditory, and tactual displays, other sensory channels are available and invite the role of utility. As a single example one may note that olfactory displays are already in use to warn of the presence of noxious gases, escaping refrigerants, etc.

The foregoing mention of knob design can serve to introduce the second major area of human engineering, which has to do with the design of machine controls for optimal human use. Here the information which we have is neither as great nor as well organized as in the area of the design of machine displays. All too often we find that research done in the area of control design has yielded information which does not fit the results of other investigations. It is difficult to perform research which yields immediately applicable data in this field because, as we pointed out earlier, prediction of the over-all performance of a man-machine system depends upon knowledge regarding all elements in the system. In a control system, however, both the man and his machine must be regarded as transmission elements, and little basic information concerning the transmission characteristics of the human operator, his operating ranges, and his susceptibility and adaptability to expected operating conditions has been available. Consequently, a great deal of current research in the area is basic in nature and has yet to be systematized to the point at which broad principles are available for application to control design.[8, 17-23]

The information available concerning the design of machine controls for human use may be discussed under two general headings:

1. *The design and layout of the work place.* A great deal of the data which the human engineer draws upon when considering the design and layout of the work place has been made available by applied anthropologists, industrial engineers, and motion and time study specialists.[9, 10, 24]

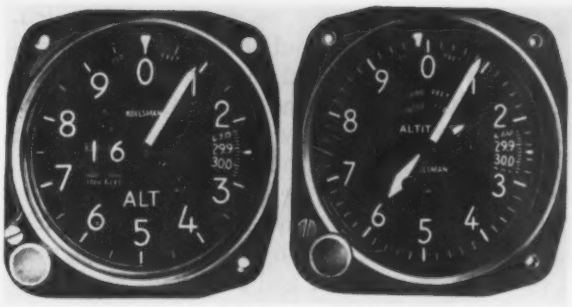


FIG. 5. Left, redesigned altimeter face now in use; right, old-type altimeter face responsible for many accidents (after Grether).

Anthropologists have accumulated great masses of data concerning almost every bodily dimension of various large as well as selected populations. In addition, they have established norms for many different human functions in answer to questions such as the following. How much can a man lift? How much can he push and pull in standing, sitting, or prone positions? How far can he reach, and in which planes are reaching and other motions most accurate? Data like these are all-important in designing seats, aircraft and automobile

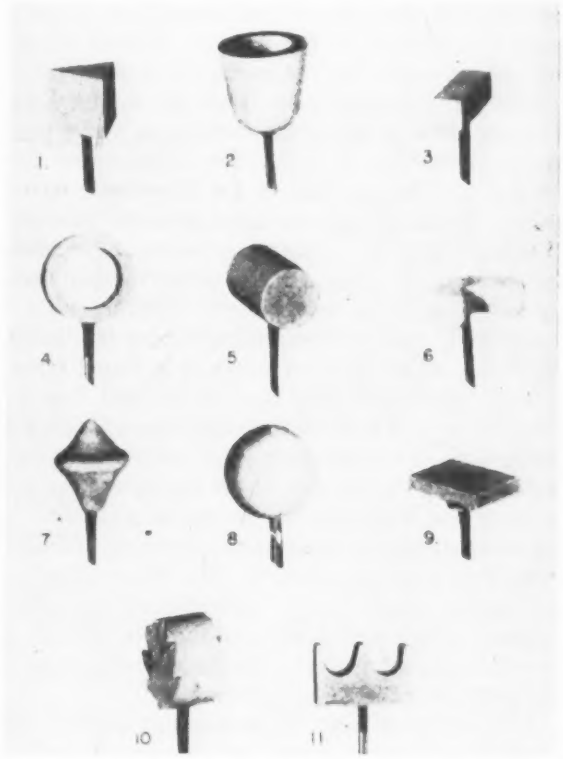


FIG. 6. Eleven experimentally selected knob shapes that are rarely confused with each other. (After Jenkins; used by permission.)

controls, etc., and need no further elaboration.

Industrial engineers and time and motion specialists have supplemented and extended the kinds of data obtained by the anthropologist. Principles of work place layout have been established which incorporate information on the bodily dimensions of the human operator, as well as the principles of time and motion economy. In addition, the field of time and motion economy itself provides such a wealth of data useful and important to the human engineer that it would be impossible adequately to sample the area with the brevity demanded here.

2. *The use of the human body.* We have already indicated that the human operator has been conceived of as, or as a part of, a servomechanism. As a matter of fact, our description of human engineering has been based on the treatment of the human operator as a link in a servo-system the over-all characteristics of which can be specified only after specification of the characteristics of all the links. Since Norbert Wiener published his book *Cybernetics,*[25] however, engineers have been much concerned with the question of whether the human operator does, in fact, behave like a servomechanism, not simply as a part of one. In any servo-system, the input drives the output, and the input is corrected by the amount of error or deviation between what the input was and what the output was intended to be. Thus the output feedback, or error, is led back to the input, and a continuous correction is made. The analogy that has been drawn here is that of the kinesthetic spinal reflex wherein the sensory input provides information regarding the extent of a muscular response, which in turn gives further sensory input and thereby directs the response even further.

Certainly many other analogies may be drawn. In studies of the human being as a closed servo-system, however, it has been discovered that he reacts in a very complicated fashion and that the mathematical representations of man as a servo-system are probably not linear equations. At the present time, therefore, we are not in a position to say whether the human control operator functions exactly as a servomechanism. Yet the concept of the human operator as an element in a servo-system appears to be a useful one, and the specification of the characteristics of the human element remains the province of human engineering.

Directed at a better understanding of how the operator operates, a great deal of research on human motor and perceptual motor skills is under way. Among the questions here are: How rapidly and accurately can a man track a moving target? With what sorts of control members (knobs, wheels, cranks, levers) is he most facile? What should be their dimensions for optimum performance? How accurately can the operator duplicate certain control forces and what force-displacement relations should be incorporated in control member design?

The area of motor and perceptual motor skills has been further complicated by the advent of high-altitude, high-speed aircraft in which excessive acceleratory, or high "g," forces are common. In addition to protecting the operator from excessive g, it is necessary to design control members that can be operated by bodily members made heavy and sluggish by the effects of high g.[26]

Although our treatment of the use of the human body and motor skills has been somewhat spotty, there is to be found quite a large body of more or less integrated detailed data. Current research on motor and perceptual-motor skills is progressing so rapidly at several research centers that it is the fastest growing area of human engineering and may shortly become the area of most concerted research effort.

In our dash through the field of human engineering we have touched upon only two of the major areas, those of machine display and machine control. Other topics we should have considered have to do with the effects upon human performance of various physical aspects of the environment, such as temperature, ventilation, humidity, noxious gases, noise, motion, and light.[1, 9, 27] Communication systems and theory should have been discussed.[13, 14] It would have been a pleasant vagary to speculate on the human engineering aspects of interstellar flight,[28] but let us conclude simply by restating that one of the important phenomena of the past decade has been the recognition of how important the human factor is in engineering design, and noting with satisfaction the large and numerous contributions which engineers, psychologists, and biological and medical scientists are making toward the solution of these newly realized technological problems.

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SMO ON THE AIR

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BOOK REVIEWS

THE NEW WORLD PEOPLE

Indian Tribes of Aboriginal America. Sol Tax, Ed. x + 410 pp. Illus. $7.50. University of Chicago Press, Chicago. 1952.

THIS volume, together with two previously published by the same press, *The Civilizations of Ancient America* and *Acculturation in the Americas,* constitutes the published proceedings of the XXIXth International Congress of Americanists, which was held in New York City, September 5–12, 1949. Although the title of this third volume may be somewhat misleading, its forty-nine component papers have this in common: They deal with general or specific problems concerning the native tribes of the Western Hemisphere dwelling outside the area of complex cultures (civilizations) in terms of their aboriginal characteristics, unmodified by European influences of the historic period. Robert H. Lowie, in the initial paper, points out the great diversity exhibited by cultures of these more backward peoples of the New World. Succeeding papers are arranged by the geographical locus of their subject matter, from North to South, beginning with the Eskimo and ending with lower South American tribes. Regional coverage is uneven. The tribes of North America receive more attention than those of the southern continent. Yet the tribes of some large North American areas, such as the Great Plains and California, receive little mention, whereas five papers are devoted to aspects of the Eskimo problem as viewed by archaeologists, a physical anthropologist, a linguist, and a student of art styles.

In reviewing the problem of the origin and development of Eskimo culture, particular attention is given to the recently described Ipiutak culture of Point Hope Alaska, characterized by its flint industry, use of iron, and high development of realistic as well as geometric art. Although some students of the Eskimo problem favor an Old World origin for Ipiutak and would date this culture earlier than previously discovered Eskimo cultures in the Western Arctic, others prefer to regard it as contemporary with the Old Bering Sea culture. The problem of the origin and sequence of Eskimo cultures and their relationship to Old World cultures, on the one hand, and American Indian cultures on the other, remains a lively one.

Of the papers devoted to the North American Indians, J. Charles Kelley's suggestion of an overland route by which certain elements of aboriginal culture were diffused from prehistoric Mexico to southeastern United States is especially fascinating. Reasoning from what is known of trade and cultural contacts in the hiatus zone during early historic times, he has suggested that earlier diffusion of ideas and trade products may have occurred through the territory occupied by the simple hunting-collecting cultures of the Coahuiltecan Indians and closely related tribes with which the outposts of both Mexican and Southeastern cultures were actually in contact.

Turning to the southern continent, Theodore D. McCown points out that the difficulty of accessing reputed finds of ancient man in South America lies not in the physical anthropologist's unwillingness to consider the possibility that relatively modern skeletal forms might have been of considerable antiquity, but in the lack of thorough knowledge of the geological contexts in which these finds occurred, so necessary for dating human remains.

The other papers in this volume further demonstrate the variety of techniques now employed by physical anthropologists, archaeologists, linguists, and ethnologists in seeking solutions to the varied problems pertaining to the origins, developments, and relationships of the native peoples of the New World. Anthropology is a field of ever-increasing regional and methodological specialization. The individual specialist needs these convenient summaries of the findings of other specialists to broaden his own outlook. At the same time the interested layman will find in these brief papers readable reports of recent progress in American Indian studies.

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EVERY LIGHT HAS ITS SHADOW

The Aurorae. L. Harang. x + 166 pp. Illus. $4.50. Wiley, New York. 1951.

HARANG'S *The Aurorae* summarizes certain features of this interesting subject but unfortunately omits other equally important phases. The book will doubtless be useful as a guide for making and interpreting auroral observations, but several other available volumes present the problems of the aurorae far more effectively. S. K. Mitra, for example, in *The Upper Atmosphere* gives a much better physical discussion of the upper atmosphere, with special reference to the aurora and the night sky. And yet we do not even find Mitra's name in Harang's book, either in the index or in the bibliography.

The book has all the appearance of having been a *Festschrift* for the great Norwegian contributors, Störmer and Vegard. These authors receive, respectively, 46 and 39 references in the index. Harang, Krognes, and Birkeland each have 12. The only non-Norwegian to collect any appreciable number of references is Sydney Chapman, with 10. And yet the all-important two-volume work of Chapman and Bartels on geophysics is not even mentioned.

Not only does the author seem to go out of his way to avoid reference to anyone but the Norwegian workers, but references later than 1937 are extremely rare and are confined almost wholly to Harang himself. I found only one reference to a non-Norwegian worker listed later than 1940—a 1947 letter to *Nature* by Lovell (one of the editors of this book), Clegg, and Ellyett.

Even apart from the heavy bias of the author, the text is disappointing. There is no real discussion of the physics of the emission of auroral lines, although their forbidden character is pointed out. Transition probabilities are given, but there is no reference to the basic work of Condon or of Pasternack.

Harang publishes Vegard's table of identifications of auroral lines and bands almost without comment. This table includes some very remarkable identifications, such as the several forbidden lines of O III, which normally appear only in the highest conditions of excitation. Various people have questioned these identifications, but if they do appear in aurorae, the conditions of excitation must be far greater than anyone has suspected to date. Harang's comments here are as uncritical as elsewhere. He adopts a similar uncritical attitude in presenting the rudiments of Milne's long outdated theory of the emission of calcium clouds from the sun under the action of radiation pressure, and although he does homage to Störmer in presenting the latter's well-known theory of the spiraling of charged particles around magnetic lines of force, he does not really emphasize the fact that the theory has long been superseded by others.

As a discussion of the prewar Norwegian contributions to the knowledge of aurorae, the book is adequate. No one can deny that the contributions are fundamental and that they comprise a sizable part of our knowledge. It is unfortunate, however, that this volume should have been the first in what has promise of being an important series for physicists in astrophysics—namely, "The International Astrophysics Series."

In fairness to the author and the editors, I may say that the book will be useful, as it does contain a great deal of material in a highly condensed form. Even so, it is regrettable that it was not brought up to date.

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GARDENING AND ARBORICULTURE

Gottfrieds Pelzbuch. Gerhard Eis. *Studien zur Reichweite und Dauer der Wirkung des mittelhochdeutschen Fachschrifttums.* (*Sudosteuropaische Arbeiten*, 38.) Callwey, Brunn, Munchen, and Wien. 1944; Winter, Heidelberg, 1951.

ANYONE studying early German works on agriculture and gardening is apt to be impressed by the repetition of certain ideas and instructions, often in almost identical phraseology. Some of these are traceable to the Latin agricultural classics, and others are apparently of medieval origin. Although greatly varied through assimilation of local folklore, these likenesses are so common that it is evident (to this writer, at least) that there must have been an extensive manuscript collection of arboricultural data from which they were largely derived.

Gottsfrieds Pelzbuch proves to be the chief if not the only source of these recurrent recipes, including local superstitions that caught the popular ear and became almost inseparable from the practical directions. The wide influence of this work is shown by the large number of extant manuscripts, fifty-seven of which have now been located by Dr. Eis; others will doubtless yet be discovered. These represent many dialects and illustrate changes that occurred in the translation and copying of the work among peoples of German, Czech, Polish, Hungarian, and other stocks in central Europe.

The oldest codex that can be closely traced, which dates back to the third quarter of the fourteenth century, is reproduced entire, together with a complete text of the fifteenth century and several partial ones of special interest. The author's name, Gottfried von Franken, so called from his native locality of Franconia or Bavaria, is not found in most of the manuscripts, so he is never cited by name; but his ideas are quoted extensively in the printed literature of agriculture and natural history down through the seventeenth century. Eis has found many parallels, and some almost verbatim quotations from Gottfried, in scores of writings in various languages, including the works of Colerus, Lauremberg, Lonitzer, Heresbach, Mizauld, and even Francis Bacon's *Sylva sylvarum.*

Some knowledge of Gottfried's characteristics can be discovered from the *Pelzbuch,* some texts of which have a clear and vigorous style, indicating his independent and forceful personality, which was doubtless an important factor in the dissemination of his teachings. He mentions localities in his native region of central Europe, but he was widely traveled—possibly as one of those itinerant gardeners who went about grafting other people's trees in the Middle Ages. He was not only familiar with the classic modes of propagation known to the Romans, but had gathered variations and a few novel practices in his wanderings, which ranged from Greece and Calabria, in the toe of Italy's boot, westward as far as Brabant.

Dr. Eis has carefully investigated the possible sources of his work and concludes that, although he was somewhat literate, Gottfried did not compile from the works of Cato, Varro, and others—that his whole work was the product of his own experience and observation. Some of his descriptions—for instance, on classic modes of budding—seem to me very close to those of Columella; yet it is possible that Gottfried was so expert in his craft that he followed the order of these procedures, which are simple and clear, without having even read the Latin originals. At any rate, he was equally good in presenting the more novel methods he had collected; it does not appear that he actually invented any that had not been practiced before.

Although his practical directions are interspersed with a few bits of superstition, he did not necessarily accept the latter; indeed, some of his comments indicate that he had not tried out certain recipes, but had set them down as they were given him. It is impossible to separate completely the folklore from the commonsense precepts—partly because Gottfried's text is condensed and sometimes altered in transcription, and also because some of the more fantastic ideas may contain the germinal principles of procedures that later proved entirely practical. Gottfried was evidently progressive and experimental, although some of his results appear rather vague.

His manuscripts originally comprised a fruit book and a *Weinbuch,* and the latter, which is lacking in many copies, exists in many independent codices, and must have been the basis of most of the early printed works on viticulture and wine making. The *Pelzbuch* is extracted in numerous old booklets on gardening and arboriculture. In my opinion, all the very early literature of gardening should hereafter be considered in relation to it. Both because it is the clue to the contents of many later works, and also because it is definitely the first comprehensive manual of the arts of propagation, *Gottfrieds Pelzbuch* is a notable discovery.

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PRACTICE IN RESONANCE

Quartz Vibrators. P. Vigoureux and C. F. Booth. xii + 371 pp. Illus. $6.75. H. M. Stationery Office, London; British Information Services, New York. 1950.

HERE we have excellent coverage of an important subject, with both theoretical and practical aspects included. This volume is a well-considered expansion of an earlier work by one of the authors, on *Quartz Oscillators and Resonators,* and adequately accomplishes the aim set forth in a portion of the preface thus: ". . . that both the reader who wishes to obtain a broad view of the problems involved and the reader who requires closely detailed information can obtain satisfaction."

Seldom in any field do we find exposition of both the science and the art thereof capably summarized in a single volume. This has been accomplished here to the extent that the book should be appreciated by anyone who is interested in the field of piezoelectricity; it should be of greatest value to the specialist engaged in the fabrication of quartz crystal units for use in electrical circuits, as either a reference for the old-timer or a text for the neophyte.

The opening chapters deal with the properties, occurrence, and examination of natural quartz crystals and include descriptions of methods and apparatus suitable for evaluation of the raw material. Discussions of piezoelectric phenomena and theory of quartz resonators and oscillators are then presented. The authors have noted many sources of information and, for more extensive study, refer to the works of themselves and of others, as listed in the comprehensive bibliography. This type of treatment continues throughout the text, as is to be expected when one views the scope as well as the summarizing nature of the book.

Subsequent chapters are concerned with types of quartz crystal plates and their associated thermal coefficients, as well as the relationship of vibration modes to means of mounting. Specification and testing, aging phenomena, temperature control, frequency standardization and control, ultrasonics, filter networks, as well as less familiar aspects such as luminous resonators, pressure gauges, and accelerometers, are covered to somewhat the same degree as subjects in the earlier chapters.

The remainder of the volume is devoted to detailed exposition of production methods suitable for use in manufacturing quartz crystal units in quantity. Here one of the authors draws upon experience gained in the United Kingdom quartz industry, and describes the several fabrication techniques that have been used in the manufacture of quartz elements. It is pointed out that many variations of production methods have been successfully used; here again liberal use of references is made, with due acknowledgment as to source and inclusion thereof in the bibliography. The appendices also include useful information and design data, again typical of the general trend toward handbook summary so characteristic of the volume.

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DEMOCRATIC VISTAS

The Development of Economic Thought. Henry William Spiegel, Ed. xii + 811 pp. $6.50. Wiley, New York. 1952.

IN HIS splendid book *Modern Democracy,* Carl Becker observes that in approximately six thousand years of recorded history the appearances of democracy have been fleeting and tenuous, that democracy as a form of social structuring is a delicate balance of factors of which none can be ignored without threatening the existence of the very fabric of democracy itself. The brilliant though brief appearances of democracy attest to the supremely difficult task of fulfilling the basic requirements of its growth. As Judge Learned Hand recently observed, perhaps our time is one of those periods in history when democracy is moving into eclipse, to be replaced by the clever maneuvering of the demagogue and the dextrous manipulator of mass-minds.

For a hundred and fifty years Europe struggled with the thorny problem of achieving political democracy, only to attain it in fractional form. The perennial problem of achieving economic democracy as the implementation of ethical and political democracy or, to

put the matter differently, the equation of human equality and economic equality, cries out for solution; it will not be stilled. The history of ancient Israel and the early Christian communities indicates that man has long been sensitive to the intimate relationship between human equality and economic questions. Aristotle realized that political democracy was little more than a verbalism without relation to the necessary economic climate in which it must develop.

Democracy, however, is not necessarily coupled with any particular economic structure, either communal ownership of the means of production or laissez-faire capitalism. In whatever economic context it finds itself, democracy strives for the possibility of a higher standard of living for all as against great inequalities of wealth and lack of sufficiency for the masses of men. The philosopher Spinoza grasped the situation accurately when he wrote: "The final end of the State consists not in domination over men, restraining them by fears, subjecting them to the will of others. The State . . . has for its end so to act that its citizens should, in security, develop soul and body, and make free use of their reason. Hence the true end of the State is liberty." The extent to which our citizens are unable "in security [to] develop body and soul, and make free use of their reason" is a measure of our failure to fulfill the purposes of democracy. As someone has put it: Freedom should not be made less but it must be made wiser.

Against the swift current of hysteria and complacency, freedom precariously threads its way. Spiegel's anthology can be of real use in assisting us to understand the complex economic forces which form the broad and insufficiently charted waters upon which the tiny boat of democracy sets its sails. Rather than offer the reader a commentary based upon a commentary, Spiegel bids his readers address themselves directly to the thinking of economists ranging from Aristotle to Colin Clark, by reading these men, not reading *about* them. There are freshness, sparkle, and intellectual give-and-take derived from wrestling with an author quite lacking when one reads second- and third-hand commentaries. If Spiegel's book stimulates us to refresh our own thinking with respect to the persistent problems of democracy and the basic economic questions that attend them, he will have rendered a real service in the publication of his anthology.

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EARTH'S ORIGIN

Geology. O. D. von Engeln and Kenneth E. Caster. xii + 730 pp. Illus. $7.00. McGraw-Hill, New York–London. 1952.

THE considerable number of good geology texts that have appeared since the war is a healthy sign, not only of increasing interest in the subject by the public, but also of increasing interest on the part of geology teachers in presenting their information in the most effective way. The latest arrival is the excellent and novel text by O. D. von Engeln and Kenneth E. Caster, bearing the simple title *Geology*. The publishers have fulfilled their part in producing a first-quality text by providing excellent format and well-executed illustrations, from the thought-provoking cover to the last figure, including two beautiful color plates. The use of boldface type for paragraph titles and also to call attention to technical terms on their first appearance will prove helpful to students.

The book contains numerous references to individuals who have made important contributions to geology. The 700 pages are divided equally into physical and historical geology. In the preface the authors state that they expect "The student will recognize that what comes next should come next." This has been laudably achieved, especially in the first half of the book, where each chapter depends on and logically follows what precedes it. This is not a text that an instructor can easily make fit some other sequence of topics that he prefers.

The text is predominantly, although not exclusively, of a descriptive nature. Sets of questions distributed strategically throughout the book are designed to impel the student to recall what he has read. Rarely do they lead him to inductions he might reasonably make. Valuable lists of supplementary books are placed at the end of each chapter.

The latter part of the text is unusual in tracing geological history from the Pleistocene back to the Cryptozoic Eon and on to theories of earth origin. The continuity between physical and historical parts is maintained by making glaciation the last topic in the former, which naturally leads to consideration of Pleistocene phenomena. This latter part of the text leaves this reviewer with the sort of impression that Alice must have experienced when she found herself behind the looking-glass. Whether the inverted order, in which dinosaurs must become extinct before the student has become acquainted with them, and the Appalachians folded from geosynclinal sediments of which the student has no knowledge, will become a popular one remains to be seen. Even the authors occasionally find it difficult to express this "looking-backward" attitude, as shown in a slight misstatement on page 485 in dealing with migrations of geosynclines. As a whole, the presentation is clear and comprehensive, and it deserves, and will doubtless receive, wide consideration.

Every first edition, I suppose, has statements the author would like to alter. One such is the definition of hydrolysis on page 94. A few others will be found, but they are very infrequent. Perhaps it is too much to expect that, after stating on page 507, "The Atlantic Basin is presumed to have been created in the late Triassic," the very next map of Permian time (p. 528) should *not* show an Atlantic Ocean.

There is much to commend: clear definitions, an admirable tentative attitude in presenting controversial

topics, very up-to-date information, worldwide coverage. The minor errors are easily detected and they will be corrected.

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BIOLOGY TREATED AS A WHOLE

The Biotic World and Man. Lorus J. Milne and Margery J. Milne. 588 pp. $6.75. Prentice-Hall, New York. 1952.

THE list of general biology texts is now so long that additions to it require strong justification. For many years, biology texts became increasingly encyclopedic. When they reached a point where their contents extended way beyond what could ordinarily be covered in a college course, and reading them became difficult even for the instructors, a swing in the other direction began. A series of texts resulted that were dedicated primarily to simplified presentation and to readability, frequently at the expense of adequate presentation of facts and principles.

The justification of *The Biotic World and Man* would appear to be its design to be selective in content but still to cover the basic principles of biology as they relate to man as the central figure, and to do this in a book distinguished by attractiveness and readability. Excellent photographs constitute the most striking feature of the book. It can probably be argued that some of them contribute little or nothing to the establishment and teaching of biological principles, but they are handsome and well handled, and they will be effective in stimulating interest in the general student and the layman. This stimulation of interest is one of biology's problems. The drawings are less uniformly good and impressive, but many of the diagrams do much to assist the reader in grasping complex relationships—structural and functional.

Neither the content of the book nor its plan of presentation differs significantly enough from those of other texts to warrant comment. To the general reader or the student who wants his appetite for biological science whetted, or to the teacher with problems of presenting basic principles in a relatively short course, *The Biotic World and Man* can be recommended highly. As a text, it is neither complete nor searching enough for serious foundation courses in biology. Such courses present special problems, and their purposes are too frequently confused with that of giving a general background in biology to the students whose interests do not lie primarily within the biological sciences, or even the sciences.

For various reasons, the plant sciences have in some respects lagged behind the animal sciences. Related to this fact is the failure of most basic biology texts to give a really adequate picture of either the basic importance of plants or our knowledge of their structure and functioning and the contribution of this knowledge to general biological principles. *The Biotic World and Man* is unfortunately no exception to this pattern of deficiency.

One of the outstanding features of the book is its presentation of biological principles without recourse to use of too much of the biologist's specialized and often difficult language. Not only has the language problem been avoided, but the book reads well and reflects real ability to present simply subject matter that is often of involved nature. For many biology offerings this book should serve a very useful purpose.

W. GORDON WHALEY

The Botanical Laboratories
The University of Texas, Austin

BRIEFLY REVIEWED

A Field Guide to Shells of the Pacific Coast and Hawaii. Percy A. Morris. 220 pp. Illus. $3.75. Houghton Mifflin, Boston. 1952.

ONCE again Percy Morris has given the amateur conchologists a handy field guide to seashells. This new identification book fills a long-standing need for a well-illustrated and simply written survey of the common shells of our Pacific coast. Through the help of John Q. Burch, of Los Angeles, the author has handled the scientific names of 353 Eastern Pacific shells with almost complete accuracy. Californian collectors should have little difficulty in recognizing most of their finds either in the text or among the many illustrations.

The last quarter of the book deals with some of the marine shells found in Hawaii. In a sense, it might have been well for the author to have devoted these last few pages and the four colored plates to the Pacific coast shells. The sprinkling of Hawaiian forms does not do justice to the vast and interesting Indo-Pacific molluscan fauna, and the author has committed numerous errors of identification, especially among the gastropods. The illustrations of the Hawaiian species (including a few not known from Hawaii) are excellent.

R. TUCKER ABBOTT

U. S. National Museum

Insight into Astronomy. Leo Mattersdorf. 223 pp. Illus. $3.50. Lantern Press, New York. 1952.

LET there be no complaint that the president of the Amateur Astronomers Association has written an elementary book on astronomy. He intended it so. For anyone wishing knowledge beyond this simple, clear exposition of the stars in their courses, a suggested reading list is appended. But, with very few technical terms, the book gives the beginner a thorough acquaintance with all that is now known, and suggests future fields of exploration.

Mr. Mattersdorf opens the book with a description of the vast spaces and distances in the universe. He goes on to tell what is known of the lifeless moon and its craters. Next comes the sun, sunspots, and the source of the tremendous heat. The planets, with their moons,

lead directly to the speed of light and to Bode's law. The story becomes more interesting as the little planets, "the asteroids," are identified. Then the method of discovering them by photography, the measuring of space by the "astronomical unit," takes our attention.

Comets and meteors, the theories of their origin, content, and possible danger to earth, come next. Zodiacal light and "counterglow" are not known to everyone. Nor is it generally known that important stellar secrets are revealed by the spectra of the stars. When the book reaches the constellations, the author prefers to point out the configurations (as first described by the ancients) rather than to use charts. However, there are a few charts and many excellent photographs, particularly of the Milky Way and other galaxies.

It is shown that astronomy is essential to navigation, to the calendar, and for accurate time. The sextant is explained along with the newer loran and shoran stations and charts. Tides, eclipses, and the "great year" conclude a splendid book that should lead many a youthful astronomer to further study.

MARJORIE B. SNYDER

Washington, D. C.

A Hundred Years of Anthropology. (2nd ed.) T. K. Penniman. 512 pp. $5.00. Macmillan, New York; Gerald Duckworth, London. 1952.

THIS somewhat pedestrian history has been revised by substituting a new final chapter, adding a supplementary bibliography, eliminating two appendices, and making "minor emendations" in the original text. The latter have been very minor indeed; of three specific errors mentioned by Leslie White in a review of the first edition, one has been corrected.

The new final chapter deals with anthropology since 1935 in five sections: Prehistory and Technology in the Old World; Physical Anthropology since 1935; A Review of Developments (by J. S. Weinert); Americanist Studies (by Beatrice Blackwood); General Ethnology and Social Anthropology; Postscripts. For various subtopics the most important contributions published since 1935 are mentioned, together with some indication of significance, but interpretation is minimal.

The section by Weinert is the best. The new genetical approaches are concisely presented, with good exposition of present significance and future potentialities. At the same time, older approaches are not discounted; emphasis is rather on the ways in which their data and methodologies may be reorganized and redefined. In her section, Miss Blackwood comments that: "As regards the study of the present, there is a tendency, more pronounced, perhaps, in America than in England, for the writings of Anthropologists, for good or ill, to become indistinguishable from those of the sociologists on the one hand, and of the psychologists on the other" (p. 413). These are excluded from consideration and hence a very large part of the anthropological work in the United States in the past seventeen years is not mentioned, although it receives brief treatment later by Mr. Penniman. Miss Blackwood's section, then, is little more than a catalogue of archaeological and ethnological work: except for the portions on Early Man and on Special Topics, the treatment is areal.

The treatment of social anthropology by Mr. Penniman is particularly unsatisfactory. American social anthropologists are regarded as being quite different from the British, and the great influence of Malinowski and Radcliffe-Brown upon them is ignored. In discussing British social anthropologists, Malinowski and Radcliffe-Brown are simply lumped together as functionalists, and there is uncritical repetition of old clichés. British social anthropologists are praised for their insistance upon the study of cultural wholes, despite the fact that nearly all their modern works are intensive treatments of special aspects of society. On the other hand, Penniman concludes with the interesting—although somewhat unorthodox—view that the ultimate aim of all branches of anthropology is ethnology, "which helps us to understand people as they are and as they have been."

Anthropologists will find the revised edition as unsatisfactory as the first. The lay reader (for whom the book is primarily intended) will find the work an excellent selective bibliography, arranged topically and in time, and will get some sense of the major findings. On the other hand, he will learn little of the most important theoretical and methodological problems, nor will he acquire any sense of the controversies, the ebb and flow of ideas, which are the essence of the history of any science.

RALPH L. BEALS

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University of California, Los Angeles

Inorganic Chemistry. Therald Moeller. ix + 966 pp. $10.00. Wiley, New York; Chapman & Hall, London. 1952.

TEACHERS and students of inorganic chemistry are encompassed in a vicious circle. For some time we have suffered because no good text of inorganic chemistry has been available; therefore, not properly introduced to its present problems and future possibilities, few have been able to initiate the tedious self-study required to comprehend the present status of this science. The few masters of the subject have been, perhaps properly, engrossed in studying various facets of particular interest to them and have not told the rest of us about the broad aspects of their science by writing a text.

A good text in any scientific subject, and especially so in inorganic chemistry where the need is so pronounced, should first explain the currently acceptable theories and describe their development from experimental facts. Further, it should indicate the applications of these theories and emphasize their limitations. Finally, it should point out the areas where no adequate theories exist and, if possible, suggest various

approaches to the solution of these unsolved problems.

This text fulfills the first requirement quite satisfactorily, and considers several applications of the theories presented, but the student is not at any time overtly challenged to get busy and seek out the undiscovered relations himself, to add to the stature of this potential capstone of chemistry, to be the Aquinas of inorganic chemistry. Today, with restive students preoccupied with the state of the world, we need forceful challenges; tacit hints go unheard.

Nevertheless, not only because it is timely, but because it is otherwise a good book in many respects, Moeller's book is recommended as a text. Part one treats general principles: the nucleus, extranuclear structure and properties derived therefrom as related to the periodic table, complex ions and coordination compounds, redox reactions, acids and bases, and nonaqueous solvents. Part two is descriptive in character, each chapter considering the elements and their intragroup relations, properties and preparation of the free elements, and an extended, orderly discussion of the important compounds of the elements. These chapters discuss the inert gases, hydrogen, the halogens, the chalcogens, the nitrogen family, the carbon family, the boron family, group IA and B, group IIA and B, the transition elements, and the lanthanide and actinide series.

More than 2000 references to the literature, supplemental reading suggestions at the end of each chapter, an author index, and a thorough subject index were gratefully noted. Well-chosen prefatory and interjacent statements tended, with some success, to relieve the dryness that usually accompanies inorganic texts. Excellent structure diagrams and graphs have been liberally used. Frequent cross references to preceding and following textual material will be helpful to the serious student.

Although this text could be used by advanced undergraduate students, is seems to be better suited to the graduate level. This reviewer intends to use it in a two-semester course, disagreeing with the author's implication that it can be covered in one semester.

JAY A. YOUNG

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Ecological Crop Geography and Field Practices of the Ryukyu Islands, Natural Vegetation of the Ryukyus, and Agro-climatic Analogues in the Northern Hemisphere. M. Y. Nuttonson. 106 pp. Illus. $3.00. American Institute of Crop Ecology, Washington, D. C. 1952.

THIS volume is the latest contribution to the growing list of publications of the American Institute of Crop Ecology on the agricultural ecology and the agro-climatic analogues of various countries. Previous studies covered Japan, Germany, Sweden, Norway, Siberia, and others. This analogue, or homoclime, technique, in which similar ecologic areas are identified in different countries by the comparison of climatological, geographic, and soils data, replaces to a large extent the old trial-and-error method in the selection and introduction of new varieties into a country. It provides a short cut to the crop varieties and field practices, forest and pasture ecotypes, that will improve the agriculture of less well-developed countries. In this report, for the first time, agro-climatic analogues have been formulated for the Northern Hemisphere, not merely for North America.

The book represents an enormous amount of compilation and analysis of data on climate, geology, soils, natural vegetation, crop distribution, varietal performance, plant diseases and insect pests, and field practices of the Ryukyus. The data are presented in numerous tables, charts, and maps. Climatic conditions (data on mean monthly, seasonal, and annual temperatures; average monthly, seasonal and yearly precipitation; relative humidity; precipitation-effectivity indexes and ratios) are summarized in considerable detail for each of the main islands. Year-round, April–September, and October–April analogues, found in the Northern Hemisphere, are given for each weather station of the Ryukyus. Latitudinal and thermal analogues have been found in Florida, Louisiana, Mississippi, and Alabama; and in Cuba, the Canary Islands, the Bahamas, Egypt, India, Formosa, and the Hawaiian Islands.

The natural vegetation and forest practices are described, with tables of woody and herbaceous vegetation and a vegetation map. The principal features of Ryukyuan agriculture are discussed in detail, largely on a regional basis, and include varieties, dates of planting and harvesting, major crop diseases and insect pests, and agricultural practices. A statistical summary of the chief crops is given.

The book is concise, well written, and comprehensive; it is an invaluable handbook. The author apparently had full access to numerous reports, maps, statistics, and other information, much of which is not readily available. Studies like this are needed for other countries, especially for those where foreign-aid programs to improve living conditions are contemplated or under way, for they furnish much of the basic information that is essential for sound planning.

HERBERT C. HANSON

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The Ocean River. The Story of the Gulf Stream. Henry Chapin and F. G. Walton Smith. vii + 325 pp. Illus. $3.50. Scribner's, New York. 1952.

IT IS a great and important task for men of science to convey their knowledge to the public and to communicate it in an intelligible way. This requires not only adequate professional training, but also a great deal of literary talent. A good popular scientific book must be carefully written, so that it is easy to read and attractive to the layman and so that it treats the subject in a technically sound way.

Such a book is *The Ocean River*. Usually the Gulf Stream, that important ocean current in the North Atlantic, is called a "River in the Sea;" it involves, however, not only the Gulf Stream itself, but the whole of the oceanic circulation—although the authors give the North Atlantic their main consideration. The Gulf Stream is an important part of the "Ocean River," but it is only one link in the great interlocking system of current branches and drifts.

This well-written book tells us about the sources of energy, the forces of the air and the sea that drive the "river" perpetually on its course. This giant "engine" created by climate and in close gear with its "motor," the atmosphere above it, reacts upon the air and distributes and controls the climate far from its source. Thus, directly or indirectly, it controls our lives and our food supply—the plant and animal life both in the water and on the land; and, finally, it controls our history and the civilizations of the lands bordering its course.

The authors present a readable story of the Atlantic Ocean. We see how the great earth movements molded the rocky confines of the "river," and we are told about the secrets of subocean geology—revelations which help us to understand our land-bound environment. We watch the salty waters that move within this foundation and we observe their action. We hear about the manifold life within the "river," the Age of Fishes and the Age of Plankton, and why our fisheries are linked to the movements and pulses of this tremendous current system.

A large portion of the work is devoted to a history of the exploration of the lands bordering the course of the river. Here, also, are the tales of navigators pushing forward into unknown regions of the vast sea. Adventurers followed, driven by the greed for gold. Here we find the exciting history of the West Indies, the exploration of the northern coasts, and the development of wealthy and powerful Atlantic seaboard colonies, followed by the present-day community of Atlantic peoples. Even the saga of the lost Atlantis is examined with care in one special chapter. A bibliography is given for each of the 14 chapters, and a subject and name index facilitates reading.

The book is well worth reading, not only for laymen who are interested in this rather new field of oceanography and in the history of the Atlantic Ocean, but for all scientists who like good reading about the sea.

GERHARD NEUMANN

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ASSOCIATION AFFAIRS

THE AAAS COUNCIL

THE AAAS is governed by its Council, and its business operations are directed by its Executive Committee. In the proposed revision of the Constitution and Bylaws (THE SCIENTIFIC MONTHLY, **75**, 255; 325 [1952]) this basic differentiation between the two governing bodies is clarified but definitely preserved; and at St. Louis this month the council will be asked, not only to vote on the revised Constitution and Bylaws, but also to provide guidance and to make decisions on other fundamental issues and current problems confronting the Association. A statement of these issues, as well as a description of the council and its composition, will reveal the questions that the Association is called upon to solve, and the manner in which solutions are reached.

Nearly all the 48,000 Association members are also members of affiliated and associated societies, and all but a handful have indicated a primary interest in the activities of one or two of the 16 sections into which the AAAS is divided. Through the affiliated societies and the sections each member of the Association is represented on the council. Every affiliated society—and there are 184 of them—is entitled to one representative, and those affiliates that have more than 100 members who are also Fellows of the AAAS are entitled to two council representatives. Each society representative also serves on the committee of the section with which his society is affiliated, and he provides guidance in sectional activities and has a voice in the election of section officials. Of the latter, the section chairman, who is ex officio a vice president of the Association, and the section secretary are also members of the council. In addition to these two officers from each section and the representatives of affiliated societies, eight members of the Executive Committee (elected by the council), the president, the retiring president and the president-elect, the administrative secretary, and the treasurer are council members.

The council is thus a large but broadly representative body, currently consisting of approximately 270 members, and one of the problems facing the AAAS administration is that of communication with so large a governing group. In an effort to keep the council members informed about Association activities and business, copies of the minutes of Executive Committee meetings are sent to them; they receive the agenda of the council meet-

ings held in conjunction with the annual convention, as well as the minutes of these meetings, where most of the policy-making decisions are made, and where Association officers are elected. It is the council that nominates candidates for president-elect, and which fills this office, in addition to vacancies on the Executive Committee, at regular annual elections. The business that will come before the council at the St. Louis meeting is indicated in a general way by the agenda, which will be presented with annotations so that SCIENTIFIC MONTHLY readers may follow the progress of Association affairs.

1. Election of a president-elect from nominees receiving the highest number of votes in the current runoff primary.

The president-elect is chosen from those nominees who receive the highest number of votes in a preliminary or runoff mail ballot. The president-elect succeeds the president in the active direction of Association affairs, and in his third year of service, as retiring president, he functions as the chairman of the Executive Committee, which will hereafter be known as the Board of Directors, if the revised Constitution and Bylaws are adopted at St. Louis.

2. Election of vice presidents from nominations currently being received from section committees.

Vice presidents are nominated by the section committees, which consist of a vice president, a secretary, the representatives of societies affiliated with the individual sections, and four committeemen-at-large elected by the members of the section committee. Election of the vice president is by the council but is always governed by the section nominations.

3. Election of two members of the Executive Committee from nominations made by the present Executive Committee and/or the members of the council.

Three vacancies occur in the Executive Committee each year: The retiring president is, of course, replaced by the president-elect. Of the eight elected members, all of whom serve for terms of four years, two retire each year, and this year the terms of Paul E. Klopsteg and Mark H. Ingraham expire.

4. Action on the proposed revision of the Constitution and Bylaws.

This question has been adequately covered in the pages of THE SCIENTIFIC MONTHLY.

5. The construction of a new headquarters building.

The Building Committee, of which John R. Dunning is chairman, has been actively pushing plans for the construction of a new headquarters of the Association at 1515 Massachusetts Avenue, N.W. (THE SCIENTIFIC MONTHLY, **75**, 205 [1952]), and detailed architectural plans were in process of preparation when the District of Columbia Zoning Commission, on October 23, denied the Association's application for permission to build an eight-story structure on its Scott Circle property. This decision was not anticipated and may be attributed to changes in zoning regulations since the property was purchased and to the commission's insistence on defining the terms "eleemosynary" and "educational" in its own peculiar way. Members of the Building Committee will seek council guidance and action on the steps to be taken in view of this unexpected development.

6. Consideration of the passport-visa problem.

At Philadelphia the council passed a resolution urging modification or repeal of the *McCarran Act* of 1950, as well as more judicious administration of the act by the departments of State and Justice. This year the Congress has passed the *McCarran-Walter Act*, which goes into effect on December 24. An effort will be made to review developments of the past year and to anticipate problems that may arise under the new act.

7. Reports of officers and committees, including the Executive Committee, the Administrative Secretary's Office, the Publications Committee, the Editorial Board, the Committee on Affiliation and Association, and the Cooperative Committee on the Teaching of Science and Mathematics.

Although routine in one sense of the word, these reports will inform the council of actions taken, new problems faced, and other developments that will bring the council up to date with respect to Association affairs. One special development that may be of interest to the readers of THE SCIENTIFIC MONTHLY is a request to review editorial policy, particularly with reference to the publication of such articles as those by Harry J. Fuller and Arthur E. Bestor, Jr.

8. Future meetings of the Association.

According to present plans, Annual Meetings are scheduled for Boston in 1953, San Francisco in 1954, Chicago in 1955, and New York in 1956.

It is evident that the two council sessions that will take place in St. Louis will be animated ones and will be fraught with decisions of considerable import, not only in the Association's program for 1953, but also for its future impact in American science and scientific progress.

HOWARD A. MEYERHOFF
Administrative Secretary, AAAS

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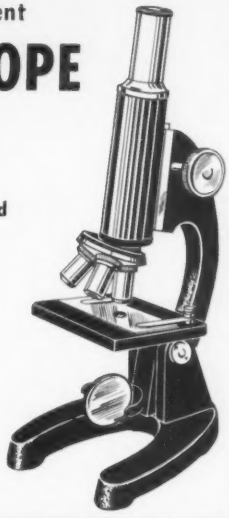

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Meetings

Dec. 1–6. National Exposition of Power and Mechanical Engineering. Grand Central Palace, New York.

Dec. 3–4. Animal Care Panel. University of Illinois, Chicago.

Dec. 4. Society of Cosmetic Chemists (Annual). Biltmore Hotel, New York.

Dec. 6–9. American Academy of Optometry (Annual). Hotel Seneca, Rochester, N. Y.

Dec. 7–10. American Institute of Chemical Engineers (Annual). Hotel Cleveland, Cleveland.

Dec. 12–13. Association for Research in Nervous and Mental Disease (Annual). Hotel Roosevelt, New York.

Dec. 23–27. Symposium on Scientific Principles and their Application in Tropical Building Design and Construction. New Delhi, India.

Dec. 26–30. American Physical Society. Naval Ordnance Test Station, Inyokern, and California Institute of Technology, Pasadena.

Dec. 26–31. American Association for the Advancement of Science (Annual). Hotel Jefferson, St. Louis.

Dec. 27–28. American Chemical Society. Division of Industrial and Engineering Chemistry, Annual Chemical Engineering Symposium. Evanston, Ill.

Dec. 27–29. American Mathematical Society (Annual). Washington University, St. Louis.

Dec. 28. International Union Against Cancer and International Cancer Research Commission. Bombay.

Dec. 28–29. Committee for the Scientific Study of Religion. New York.

Dec. 29. Society of the Sigma Xi (Annual). St. Louis.

Dec. 30. Mathematical Association of America. Washington University, St. Louis.

Jan. 9–10. American Group Psychotherapy Association (Annual). Henry Hudson Hotel, New York.

Jan. 12–16. Society of Automotive Engineers (Annual). Sheraton-Cadillac Hotel, Detroit.

Jan. 13–16. Highway Research Board (Annual). National Academy of Sciences–National Research Council, Washington, D. C.

Jan. 14–16. Conference on High-Frequency Measurements, sponsored by American Institute of Electrical Engineers, Institute of Radio Engineers, and the National Bureau of Standards. National Bureau of Standards, Washington, D. C.

Jan. 17. Symposium on Blood (Annual). Wayne University College of Medicine, Detroit.

Jan. 19–23. American Institute of Electrical Engineers (Winter General). Hotel Statler, New York.

Jan. 20–31. Inter-American Congress of Philosophy. Havana.

Jan. 22–24. American Physical Society (Annual). Harvard University, Cambridge, Mass.

Jan. 26–27. Compressed Gas Association (Annual). Waldorf-Astoria, New York.

Jan. 26–29. American Society of Heating and Ventilating Engineers (Annual). Conrad Hilton Hotel, Chicago.

Jan. 26–30. International Heating and Ventilating Exposition. International Amphitheatre, Chicago.

Jan. 30. Public Health Workshop, First District Dental Society of the State of New York. Hotel Statler, New York.

Jan. 30–31. Western Society for Clinical Research (Annual). Carmel, Calif.

Feb. 2–4. Symposium in Fundamental Biology. Michigan State College, East Lansing.

Feb. 4–6. Western Computer Conference. Hotel Statler, Los Angeles.

Feb. 5–7. Southwestern IRE Conference and Electronics Show (Annual). Plaza Hotel, San Antonio.

Feb. 12–13. Southern Weed Conference. Jung Hotel, New Orleans.

Feb. 15–17. Canadian Ceramic Society. Royal York Hotel, Toronto.

Feb. 16–19. Technical Association of the Pulp and Paper Industry (Annual). Commodore Hotel, New York.

Feb. 16–21. Pakistan Science Conference (Annual). Lahore.

Feb. 18–20. National Cotton Council (Annual). General Oglethorpe Hotel, Savannah, Ga.

Feb. 23–Mar. 10. Commission for Climatology of the World Meteorological Organization. Washington, D. C.

Feb. 24. Society for the Advancement of Criminology (Interim). Northwestern University Law School, Chicago.

Feb. 26–28. American Academy of Forensic Sciences (Annual). Drake Hotel, Chicago.

Mar. 1–6. International Congress of Military Medicine and Pharmacy. Montevideo.

Mar. 9–11. North American Wildlife Conference. Washington, D. C.

Mar. 11–Apr. 8. Commission for Synoptic Meteorology of the World Meteorological Organization. Washington, D. C.

Mar. 13–14. Alabama Academy of Science. Florence.

Mar. 16–20. National Association of Corrosion Engineers (Annual). Hotel Sherman, Chicago.

Mar. 23–27. Western Metal Congress and Exposition. Pan-Pacific Auditorium, Los Angeles.

Mar. 25–27. American Association of Anatomists (Annual). Ohio State University, Columbus.

Mar. 30–Apr. 2. Association of American Geographers (Annual). Cleveland.

Apr. 6–10. American Physiological Society (Spring). Chicago.

Apr. 6–10. Federation of American Societies for Experimental Biology (Annual). Chicago.

Apr. 8–12. American Heart Association (Annual). Hotel Chelsea, Atlantic City.

Apr. 10–12. American Association of the History of Medicine (Annual). Municipal Auditorium, Columbus, Ohio.

Apr. 12–15. Electrochemical Society. New York.

Apr. 23–24. Production Conference, Pennsylvania Manufacturing Confectioners' Association (Annual). Lehigh University, Bethlehem.

Apr. 23–25. Foreign Language Conference. University of Kentucky, Lexington.

Apr. 23–25. World Medical Association and Pan American Medical Confederation. Jefferson Hotel and Medical College of Virginia, Richmond.

Apr. 25. Foire Internationale de Liége (Annual). Liége, Belgium.

Apr. 26–29. American Institute of Chemical Engineers. Joint meeting with the Chemical Institute of Canada. Toronto.

Apr. 26–30. American Ceramic Society (Annual). Hotel Statler, New York.

Apr. 27–May 8. British Industries Fair. London and Birmingham.

GET YOUR ADVANCE COPY

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By first class mail – early in December

The General Program-Directory of the 119th Meeting of the AAAS in St. Louis, December 26–31, 1952, will be available to anyone, at cost, within the first week in December—whether he can attend the Meeting or not. This year the General Program will be much simplified in format and the Directory content increased. You will want it for your reference shelf.

Program content

1. The General Symposia: "Disaster Recovery" and "The Nation's Nutrition."
2. Programs of the 18 AAAS sections and subsections (symposia and contributed papers).
3. Programs of the more than 30 participating societies.
4. The Special Sessions: AAAS, Academy Conference, Conference on Scientific Manpower II, National Geographic Society, Phi Beta Kappa, RESA, Sigma Xi.
5. Details of the Kiel Auditorium, downtown hotels, Washington University.
6. Titles of the latest scientific films to be shown in the AAAS Science Theatre.
7. Exhibitors in the 1952 Annual Exposition of Science and Industry and descriptions of their exhibits.

Directory content

1. AAAS officers and staff for 1952.
2. Complete roll of AAAS presidents and their fields.
3. The 236 affiliated organizations.
4. Historical sketch and organization of the Association.
5. Publications of the Association.
6. AAAS Awards and Grants—including all past winners.
7. Membership figures by sections.
8. Section committees (Council members) in detail.
9. Local committees.
10. Future Meetings of the AAAS.

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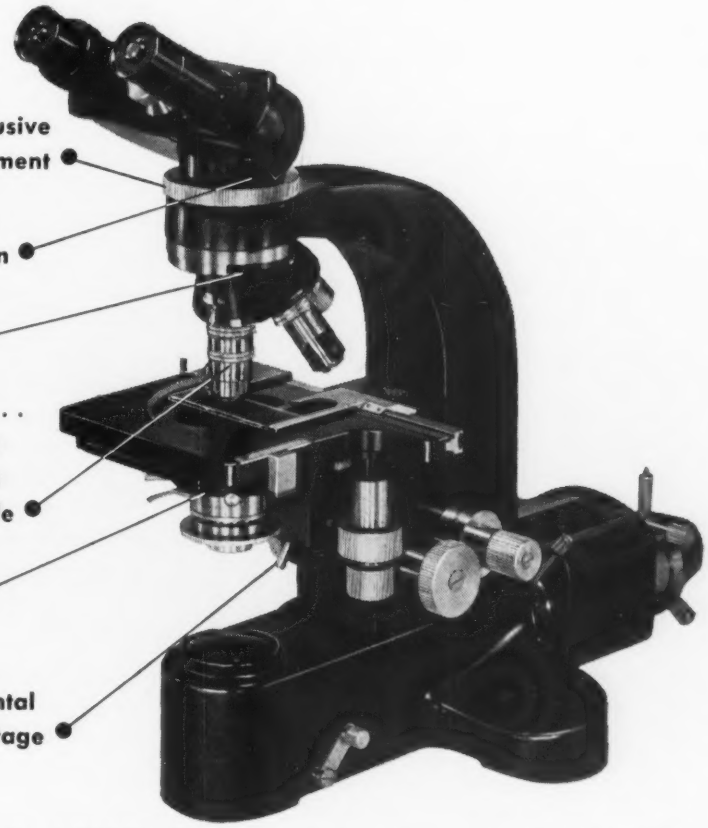

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What GENERAL ELECTRIC People Are Saying

J. P. DITCHMAN

Lamp Division

APPLICATION OF LIGHT IN AGRICULTURE: Many people are working on the use of lamps and electrical traps as a means of crop insect pest control.

Literature on the movements of insects and other responses towards or away from the light sources is very fascinating because it shows that every conceivable variation of radiant energy, spectral distribution, orientation, quantity, duration, intensity, etc., may have some action on the insects or animals. Just to mention one of these with which we are familiar, the effectiveness of the light source in attracting nocturnal insects. Researchers in this field have indicated that most nocturnal insects have receivers that are sensitive to the blue and the ultraviolet part of the spectrum. This is being used to particular advantage in agricultural fields where sources of ultraviolet and visible blue are being used to attract the cornborer moth, cotton ball worm, and others to their destruction. The fluorescent black-light lamp has been so attractive in tests conducted during the last few years that the ordinary high-voltage traps being used to electrocute the moths have been clogged by the tremendous flight of the insects. Work has not progressed far enough to recommend this use to farmers to stop the scourge of these insects, but light traps are being used as indicators to give the farmer warning when he should use control measures against the flight of any particular pest.

Am. Soc. of Agricultural Engrs.
Chicago, Illinois

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W. R. G. BAKER

Electronics Division

MANAGEMENT OF RESEARCH AND DEVELOPMENT: Just as the progress of research and development cannot be measured in monetary terms, neither can it be measured in terms of numbers of engineers, or physicists, or chemists. It must be measured in the extension of human knowledge, and in the application of that knowledge. The trend today is to shorten the time between the extension of knowledge and its application, a task which becomes more difficult as we bring more important minutiae into our understanding.

There is a growing recognition of the fact that time is a fourth dimension in scientific progress, and a dimension of increasing importance. The interrelation today of what were disassociated sciences yesterday is a strong indication that if the state of the art in one branch of science moves too far ahead, the expenditure of man-centuries of engineering effort may not produce marked further progress. A period of "catching-up" may well be required.

National Convention, IRE
New York City

★

H. A. WINNE

Engineering

RESEARCH AND INDUSTRIAL PROGRESS: The number of industrial organizations that can support programs of fundamental research in their own laboratories is not great, but it is important that all industry recognize the importance of this type of research and support it in every way possible.

The extent to which industry fosters the kind of intellectual environment that is essential to creative work will determine, in a large measure, the dividends from research that it may expect to receive over the next 50 years.

The trick is to see around the corner—or, failing that clairvoyant sense, to make a fair guess as to what may lie just around the corner and to play the research program accordingly.

A research program that is well integrated with the business interests of the company is as much a part of the continuous operation of the business as is the maintenance of a plant that is well adapted to company needs. Consequently the research program must be protected from interruptions that might follow minor fluctuations in the business cycle.

Centennial Conf. on Industrial Research
Chicago, Illinois

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